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TASK ORDER NUMBER 5TS5702D035P: TESTING ALTERNATIVE AIRCRAFT AND RUNWAY/TAXIWAY DEICERS - PHASE II

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AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7750

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U.S. Air Force installations are seeking alternatives to deicing/anti-icing fluids used on aircraft, runways, and taxiways. The current methods of deicing/anti-icing aircraft create a significant environmental compliance and pollution prevention issue for the Air Force installations, while runway and taxiway deicing/anti-icing fluids have adverse effects on aircraft and runway utilities. The objective of this study is to test the compatibility of emerging runway and aircraft deicing alternatives with various materials specific to U.S. Air Force aircraft. These alternatives are known to be more environmentally friendly than the current propylene glycol-based aircraft deicers or potassium acetate-based runway deicers, but compatibility with materials found in aircraft systems had not been determined.

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EXECUTIVE SUMMARY

U.S. Air Force installations are seeking alternatives to deicing/anti-icing fluids used on aircraft, runways, and taxiways. The current methods of deicing/anti-icing aircraft create a significant environmental compliance and pollution prevention issue for the Air Force installations, while runway and taxiway deicing/anti-icing fluids have adverse effects on aircraft and runway utilities. The objective of this study is to test the compatibility of emerging runway and aircraft deicing alternatives with various materials specific to U.S. Air Force aircraft. These alternatives are known to be more environmentally friendly than the current propylene glycol-based aircraft deicers or potassium acetate-based runway deicers, but compatibility with materials found in aircraft systems had not been determined.

Concurrent Technologies Corporation (*CTC*) identified alternative non-glycol and non-potassium acetate-based aircraft and runway/taxiway deicing/anti-icing fluids that are qualified to The Engineering Society For Advanced Mobility Land, Sea, Air, and Space (SAE)-Aerospace Material Specification (AMS) 1424, SAE-AMS 1428, and SAE-AMS 1435, in the Potential Alternatives Report dated July 12, 2002. In addition to the SAE AMS specifications, the Air Force is in the process of developing a Military Test Method Standard (MTMS) that is designed to guide and support the qualification and procurement of new ice control materials that will be acceptable for military aircraft operations. *CTC* was tasked to be the first independent evaluator to execute the material compatibility tests identified in the MTMS.

The alternative deicers that were evaluated included two aircraft deicers, METSS ADF-2 and Battelle D^3, and three runway deicers, METSS RDF-2, Clariant ®Safeway KF Hot, and Hydro Chemicals AVIFORM® L50. Overall, none of the deicers met all of the testing requirements set forth in the MTMS, although some did show little to no effect on some individual aircraft substrates.

CTC recommends reviewing the alternative aircraft deicers test data with the appropriate aircraft System Program Office (SPO) to prioritize the results and determine if potential field-testing is warranted. The Air Force, with Environmental Security Technology Certification Program (ESTCP) funding, has already field-tested the Battelle D^3 deicing fluid at the Niagara Falls Air Reserve Station (NFARS) in Niagara Falls, NY. Based on the results of this report, Phase III of this project will involve *CTC* and the Air Force coordinating the field-testing of the METSS ADF-2 deicing fluid in February 2004 at NFARS.

As the initial user of the MTMS draft standard, *CTC* also was asked to provide feedback on the documentation provided in the MTMS. A few of the tests and material substrates defined in the MTMS need to be revisited for clarification to the end-user. The items to be reviewed include: 1) the glass transition temperature test for polymer matrix composites; 2) the oxidation resistance test for the carbon-carbon brake material; 3) guidelines for procuring standardized test specimens (e.g., Infrared window, carbon-carbon brake, and polymer matrix composite materials were expensive and difficult to acquire); 4) sealant specimen preparation; 5) the open-hole compression test for polymer matrix composites; and 6) acceptance criteria for tests that are not quantitative.

1.0 INTRODUCTION

1.1 Objective

The objective of this study is to test the compatibility of emerging runway and aircraft deicing alternatives with various materials specific to US Air Force aircraft. These alternatives were developed to be more environmentally friendly than the current propylene glycol-based aircraft deicers or potassium acetate-based runway deicers, but compatibility with materials found in aircraft systems had not been determined.

1.2 Background

U.S. Air Force (USAF) installations are seeking alternatives to deicing/anti-icing fluids used on aircraft, runways, and taxiways. The current methods of deicing/anti-icing aircraft create a significant environmental compliance burden for USAF installations, and runway and taxiway deicing/anti-icing fluids also have adverse effects on USAF aircraft and runway/taxiway equipment.

Aircraft deicing and anti-icing fluids approved for use on USAF aircraft must meet the performance requirements of specifications SAE-AMS 1424 and SAE-AMS 1428. Although these specifications do not dictate the chemical composition of the fluids, until recently, the only fluids that met the performance requirements were based on propylene glycol. The biodegradation process of propylene glycol consumes free oxygen molecules in water and can stress or kill aquatic life if the concentration becomes too high. In addition to the biological oxygen demand (BOD) problem, there are toxicity concerns with the fire-suppression additives in the fluids.

Runway/taxiway deicing/anti-icing fluids approved for use on USAF airfields must meet the performance requirements of the current revision of specification SAE-AMS 1435. Again, this specification does not dictate the chemical composition of the fluids. However, the only fluids currently available that meet the performance requirement are based on ethylene glycol or potassium acetate. Because the Air Force is prohibited from using ethylene glycol for environmental reasons, the only approved alternative is potassium acetate. Although potassium acetate is relatively benign environmentally, it has been shown to have adverse, corrosive effects on some metal substrates, such as aluminum[1]. This is of concern when it is used on runways and taxiways because the aircraft brake, landing gear components, and other aluminum surfaces will be exposed and, subsequently, could corrode. Catastrophic failure of components, such as brakes and landing gear, cannot be tolerated.

Deicer qualification testing according to SAE specifications does not include compatibility with numerous specialized materials found on some military aircraft. Additional material compatibility testing is required to assess the potential impact of exposing these materials to the deicer solutions. The data contained in this report are designed to provide information to the aircraft single item managers regarding the

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[1] Gulley, Lee (1998), "Testing of Aircraft Runway Ice Control Products: Materials Compatibility," Air Force Research Laboratory Report AFRL-ML-WP-TR-1999-4040.

compatibility of the tested deicers with the weapon and support systems that are their responsibility.

1.3 Scope of Work

In July 2002, Concurrent Technologies Corporation (*CTC*) completed an effort to identify alternatives to propylene glycol and potassium acetate liquid deicing fluids for the USAF under a previous task entitled, "Identification, Development and Demonstration/Validation of Environmentally Benign Aircraft and Runway/Taxiway Deicers," (Task Order ID 5TS5702D035A). At the conclusion of that effort, a Potential Alternatives Report (PAR), dated July 12, 2002, was submitted. A few non-glycol aircraft deicing fluids and non-potassium acetate runway/taxiway fluids were identified. Those products met the applicable SAE-AMS specification, and *CTC* recommended that these products be considered for further evaluation to determine their compatibility with USAF specific substrates.

In this second phase of the effort, *CTC* coordinated with Air Force Research Laboratory (AFRL) to select five potential alternatives based on the information contained in the PAR. A test plan was developed to perform material compatibility testing on these five potential deicing alternatives. The material compatibility testing strategy focused on USAF aircraft and airfield substrates, and the technical approach was modeled after *The Qualification of Ice Control Materials for Air Force Applications*, AFRL-ML-WP-TR-2000-4149, specifically Appendix B "The Draft Military Test Method Standard" (MTMS), along with the *Testing of Aircraft Runway Ice Control Products*, AFRL-ML-WP-TR-1999-4040 (Materials Compatibility Report), for further clarification.

The five candidates, listed in Table 1, were tested under this Phase II effort to determine performance and material compatibility testing on USAF aircraft and airfield materials. These candidates were chosen based on their favorable environmental properties. Although one of the products, Battelle D^3, is not currently commercially available, it has a high degree of potential use on USAF applications, based on previous and ongoing independent test results. Therefore, the USAF determined that it should be tested as part of this task.

Table 1. Deicing Candidates

Deicers	Formulation	Availability
Aircraft Deicers (non-glycol)		
METSS ADF-2	Complex carbohydrates – from the processing of starches and sugars	Commercially available
Battelle D^3	A polyol – bio-based (sorbitol-free)	Not commercially available
Runway/Taxiway Deicers (non-potassium acetate)		
METSS RDF-2	Potassium lactate plus corrosion inhibitors	Commercially available
Clariant (Canada) ®Safeway KF Hot	Potassium formate plus corrosion inhibitors	Commercially available
Hydro Chemicals AVIFORM® L50	Potassium formate plus corrosion inhibitors	Commercially available

This test report (CDRL A012) summarizes the performance and material compatibility testing results of these candidates.

2.0 SUBSTRATE MATERIALS

Table 2 lists the substrate materials that were tested as part of this project. Further details of these materials can be found in the approved Test Plan (refer to GSA Task Order ID: 5TS570D035P, *Testing Alternative Aircraft and Runway/Taxiway Deicers Phase II Test Plan* Revision 1, dated 11 August 11 2003). Because some of the substrates were costly or unavailable at any price, AFRL directed the efforts to focus on the substrates that were available and within the budget. Materials specified by the MTMS that were not tested are found in Table 3.

Table 2. Tested Substrate Materials and Abbreviations

Substrate	Abbreviation
Metallic Materials	
A286 Steel (AMS 5731)	MT 1
4140 Steel (AMS 6395)	MT 2
C630 Aluminum-Bronze Alloy (AMS 4640)	MT 3
AZ91E Cast Magnesium Alloy (AMS 4446)	MT 4
7075-T6 Bare Aluminum Alloy (AMS 4045)	MT 5
Polymer Matrix Composites	
977-3 Epoxy Resin	PMC 1
5250-4 BMI Resin	PMC 2
Elastomeric Materials	
Nitrile Elastomer (MIL-R-6855/1/60)	EL 1
Neoprene Elastomer (MIL-R-6855/2/60)	EL 2
Polysulfide Sealant (MIL-S-8802, Type II)	SL 1
High Temperature Polysulfide Sealant (AMS 3276)	SL 2
Corrosion-Inhibiting Sealant (MIL-PRF-81733D)	SL 3
Polythioether Sealant (AMS 3277)	SL 4
Aircraft Wire Insulation Materials	
Polytetrafluoroethylene(Teflon®)	AWI 1
Hybrid Construction	AWI 2
Cable-Insulated Twisted Pair	AWI 3
Polyimide	AWI 4
Carbon/Carbon Brake Friction Materials	
CARBENIX 1000	CC 1
CARBENIX 2000	CC 2
CARBENIX 2110	CC 3
CARBENIX 4000	CC 4
Infrared Window Materials	
Aluminum Oxynitride (ALON)	IR 1
Sapphire	IR 2
Zinc Selenide (ZnSe)	IR 3

Table 3. Untested Substrate Materials Specified by MTMS

Substrate Category	Material
Metallic Materials[1]	PH13-8Mo Steel
	9Ni-4Co Steel
Polymer Matrix Composite Materials	S-2/AFR700B
Elastomeric Materials	Fluorosilicone Sealant (AMS-3375)
Infrared Window Materials	Germanium (uncoated)
	Poly-Crystalline Silicon (uncoated)
	Polymer Bond Layer (uncoated)
	Zinc Sulfide (with Pilkington's Boron Phosphide Coating – side 1 and Thorium Fluoride Anti-Reflective coating – side 2)
	Zinc Sulfide (with Raytheon's Rain Erosion Protection/Durable Anti-Reflection coating – side 1 and Yttria Anti-Reflection coating – side 2)

[1]Due to funding constraints, AFRL removed the two steel substrates (as listed in the MTMS) from testing. Based on past data it was not anticipated that any corrosion would be detected.

3.0 TESTING APPROACH

The Test Plan provides more details for the tests including quality control, laboratory data processing, and equipment used for each test. This section gives a brief overview of the tests that were conducted, any deviations from, or interpretations of the Test Plan procedure, and results of testing for each substrate category. Table 4 lists the conducted tests correlated with the substrate material, as well as the section of this report that discusses the specific tests and results.

It should be noted that these test methods are designed to represent the worst-case scenarios. In actual circumstances, due to location on the aircraft, many of these materials would be protected from direct contact with the deicers or would be equipped with a protective coating. Therefore, it is important to interpret the data based on the actual material application and its location.

This report is not intended to make judgments on the suitability of any of the products tested. It contains only data and a summary of results. No conclusions are drawn based on the data presented because there are no set standards for performance. Therefore, any determination of the overall suitability of any the tested products must be determined by the single item managers.

Table 4. Material Compatibility Tests by Substrate Category

Substrate Category	Analytical Test	Report Section
Metallic Materials	Alternate Immersion	4.1
	Stress-Corrosion Cracking	4.2
Polymer Matrix Composites	Density/Specific Gravity	5.0
	Fiber Content	5.0
	In-Plane Shear	5.1
	Glass Transition Temp	5.2
	Hardness	5.3
	Sandwich Corrosion	5.4
	Thermal Oxidative Stab.	5.5
	Percent Weight Gain After Soak	5.6
Elastomeric Materials	Shore A Hardness	6.1
	Percent Volume Swell	6.2
	Peel Strength	6.3
	Ultimate Tensile Strength	6.4
	100% and 300% Modulus	6.5
	Percent Elongation	6.4
Aircraft Wire Insulation	Conductivity	7.1
	Immersion Test	7.2
	Bend Test - Post-Immersion	7.3
	Voltage Withstand	7.4
	Wet Arc Propagation Resistance	7.5
Carbon-Carbon Brake Friction Materials	Oxidation Resistance	8.1
Infrared Window Materials	Fourier Transform Infrared (FTIR) Transmission Testing	9.1

4.0 METALLIC MATERIALS

The metallic materials were evaluated for two different types of corrosion testing including:

1. Alternate Immersion Testing – ASTM G-31 plus MTMS additional procedure information, and
2. Stress-Corrosion Cracking – ASTM G-44 (and G-49 – sample preparation) plus MTMS additional procedure information.

4.1 Alternate Immersion Testing

Test Description

Three specimens of each test metal were machined into 5 x 5-centimeter (cm) squares using electrostatic discharge machining (EDM) wire to avoid localized heating. The surface of the specimens were ground to a 32-microinch (µin) rms finish, wiped clean with methyl ethyl ketone (MEK) and weighed to the nearest milligram (mg). The specimens from a single test metal were placed in the stress corrosion cracking chamber, to avoid potential cross contamination of corrosion product(s). The chamber was programmed with the following parameters: 1) submerge specimens in deicing/anti-icing fluid for 10 minutes, 2) drain and then air dry specimens for 50 minutes, and 3) repeat steps one and two continuously for two weeks. The specimens were checked for corrosion daily during the work-week and, once corrosion was detected or two weeks had passed, the specimens were removed from the chamber. Once removed from the chamber, the specimens were weighed, examined for staining, pitting, exfoliation, and corrosion product buildup, and were digitally photographed.

Test Methodology

Parameters	5 x 5-centimeter specimens with a cycle time of 10 minutes in deicing fluid and 50 minutes air drying for 2 weeks
Type/Number of Specimens	MT 1, MT 2, MT 3, MT 4, and MT 5; 3 per substrate
Trials Per Specimen	1
Evaluation Criteria	No corrosion present or staining, pitting, exfoliating due to corrosion
Reference Document	ASTM G-31, MTMS Section 5.3

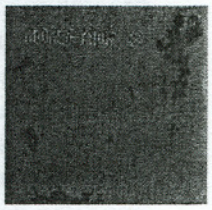
Deviations from, or Interpretation of Test Method

Both steel substrates were run simultaneously in the same corrosion chamber to minimize test time. Because both substrates were steel alloys, no cross-contamination was anticipated.

Test Results

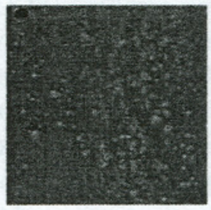
The average percent change in weight for each metal that corroded after alternate immersion exposure to the five deicers is listed in Table 5. The raw laboratory data are provided in Appendix A.

Table 5. Alternate Immersion Test Results and Corrosion Details

Substrate → / Deicer ↓	A286 Steel	4140 Steel	C630 Aluminum-Bronze Alloy	AZ91E-T6 Cast Magnesium Alloy	7075-T6 Bare Aluminum Alloy
METSS ADF-2	No Corrosion	No Corrosion	No Corrosion, bluish colored area; appears to be made from contact with paper cloth[1] 	No Corrosion, dark staining 0.24% Weight Change 	Filiform Corrosion in spots, ~10-15% 0.02% Weight Change 
Battelle D3	No Corrosion	Red Rust, light and spotty ~1%, 1/32 inch spot TDC edge <0.01 % Weight Change 	No Corrosion	No Corrosion, dark staining <0.06% Weight Change 	No Corrosion

1 – Contact with the paper cloth occurred prior to testing.

Table 5. Metallic Materials Corrosion Details (Continued)

Substrate → Deicer ↓	A286 Steel	4140 Steel	C630 Aluminum-Bronze Alloy	AZ91E-T6 Cast Magnesium Alloy	7075-T6 Bare Aluminum Alloy
METSS RDF-2	No Corrosion	No Corrosion	No Corrosion, Mottled and discolored over entire area <0.01 % Weight Change 	Pits ~35-50% of entire surface area, etching 3.79 % Weight Change 	Cloudy, stained appearance over entire surface area. 0.07 % Weight Change 
Clariant® Safeway KF Hot	No Corrosion	Red Rust, light and spotty ~5% both sides <0.01 % Weight Change 	No Corrosion, Discolored spots <0.01 % Weight Change 	Medium White Corrosion ~25-30% 1.79 % Weight Change 	White spots, 8 total <0.01 % Weight Change 
Hydro Chemicals AVIFORM® L50	No Corrosion	Red Rust, light and spotty ~5% <0.01 % Weight Change 	No Corrosion	Heavy White Corrosion ~95% 5.16% Weight Change 	No Corrosion

<u>Discussion of Results</u>

All deicers had little to no effect on the A286 steel, the 4140 steel and the C630 aluminum-bronze alloy. Battelle D^3, Clariant® Safeway KF Hot, and Hydro Chemicals AVIFORM® L50 did not cause any corrosion to the 7075-T6 bare aluminum alloy. The

METSS ADF-2 caused a 0.02% weight change with some filiform corrosion, while METSS RDF-2 caused a 0.07% weight change. METSS RDF-2 exposure also provided a cloudy, stained appearance to the surface of the test panel.

The AZ91E-T6 cast magnesium alloy was the most affected by deicer exposure. All runway deicers (METSS RDF-2, Clariant® Safeway KF Hot, and Hydro Chemicals AVIFORM® L50) caused a weight change and generated severe white corrosion over a significant amount of surface area (see the pictures in Table 4).

4.2 Stress-Corrosion Cracking Tests

Test Description

Stress-corrosion cracking (SCC) tests were performed in accordance with ASTM G-44 and the additional procedures outlined in the MTMS. First, samples were prepared according to ASTM G-49, *Standard Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens.* Specimens were placed into frames and loaded into a special stressing fixture. An extensometer was used to determine the strain applied to the specimen (target was near 80% of the measured yield). To ensure there were no galvanic effects between the frame and the specimen, the frame and threaded ends of the specimen were coated with a stop-off lacquer. The only metallic materials exposed to the deicing/anti-icing solution were the test areas of the specimens.

Once the framed samples had air dried, they were placed in the SCC chamber with the alternate immersion samples of the same alloy. The same cycle was applied to the SCC samples: 1) 10 minutes submerged in deicing/anti-icing solution; 2) drained and air dried for 50 minutes; and 3) steps one and two repeated continuously. The duration of the test also was for two weeks. The samples were removed from the chamber at the end of the test time or if catastrophic failure occurred (the specimen fractured). Otherwise, visual examinations were regularly conducted to determine if any cracking, pitting, or other discoloration occurred due to exposure. Digital photographs documented the results.

Test Methodology

Parameters	Tensile specimens strained to 80% of yield, with a cycle time of 10 minutes in deicing fluid and 50 minutes air driying for 2 weeks
Type/Number of specimens	MT 1, MT 2, MT 3, MT 4, and MT 5; three per substrate
Trials per specimen	One
Evaluation Criteria	No fracture while specimen is strained or during removal of the frame at the end of the test cycle
Reference Document	ASTM G-44, ASTM G-49, MTMS Section 5.3

Deviations from, or Interpretation of Test Method

Both steel substrates were tested simultaneously in the same corrosion chamber to minimize total test time. Because both substrates were steel alloys, no cross-contamination was anticipated.

Test Results

The average pass/fail results for each metal are listed in Table 6. The raw laboratory data are included in Appendix A.

Table 6. Stress Corrosion Cracking Test Results

Deicer	Result
A286 Steel	
METSS ADF-2	Pass
Battelle D3	Pass
METSS RDF-2	Pass
Clariant ® Safeway KF Hot	Pass
Hydro Chemicals AVIFORM® L50	Pass
4140 Steel	
METSS ADF-2	Pass
Battelle D3	Pass
METSS RDF-2	Pass
Clariant ® Safeway KF Hot	Pass
Hydro Chemicals AVIFORM® L50	Pass
C99300 Aluminum-Bronze Alloy	
METSS ADF-2	Pass
Battelle D3	Pass
METSS RDF-2	Pass
Clariant ® Safeway KF Hot	Pass
Hydro Chemicals AVIFORM® L50	Pass
AZ91E-T6 Cast Magnesium Alloy	
METSS ADF-2	Pass
Battelle D3	Pass
METSS RDF-2	Pass
Clariant ® Safeway KF Hot	Pass
Hydro Chemicals AVIFORM® L50	Pass
7075-T6 Bare Aluminum Alloy	
METSS ADF-2	Pass
Battelle D3	Pass
METSS RDF-2	Pass
Clariant ® Safeway KF Hot	Pass
Hydro Chemicals AVIFORM® L50	Pass

Discussion of the Results

All deicers had no effect on the strained metallic substrates. Stress-corrosion cracking did not occur.

5.0 POLYMER MATRIX COMPOSITES

Evaluation of the effects of deicers on the polymer matrix composites included the following tests:

1.0 In-plane Shear – ASTM D 3518 and 3518M-94
2.0 Glass Transition Temperature (also a tag end test)
3.0 Barcol Indentation – ASTM D2583
4.0 Sandwich Corrosion Test – ASTM F 1110
5.0 Thermal Oxidative Stability – MTMS 5.4.1.3.4 b
6.0 Percent Weight Gain after Soak – MTMS 5.4.1.3.4 a.

Tag end testing of the polymer matrix composite sheets was conducted before deicer exposure to determine the quality of the original manufactured composite material. These tag end tests included density, fiber content, and thermal analysis. See Appendix B for the testing procedures and results of the tag end tests.

It is important to note that the polymer matrix composite specimens were difficult to procure. The MTMS-specified testing AS4/3501-6, IM7/5250-4, and S-2/AFR 700B composites. After contacting various vendors and acquiring cost estimates, AFRL determined that the test specimen materials were too expensive. Therefore, the Boeing Company – Seattle was contracted to prepare the test specimens needed for testing. The only composites that could be provided were the 977-3 Epoxy Resin, used on the F-22, F-15, and JSF, and the 5250-4 BMI Resin, used on the F-22.

Initial Composite Preparation Procedure

Composite specimens were dried in a vacuum oven at 140-145°F for approximately 64 hours (over a weekend) and weighed to determine the "dry" weight. The specimens were soaked in deicing fluid for four hours, and then air-dried at room temperature for twenty hours. This process was repeated four times, totaling twenty hours of immersion time per specimen. The specimens were rinsed and remained at room temperature for approximately 64 hours (over the weekend). The exposed specimens then were weighed to determine the total weight gain. Mechanical testing (in-plane shear) was performed for Specimen 1 on Monday, Specimen 2 on Tuesday, and Specimen 3 on Wednesday. The physical tests (Barcol indentation hardness, glass transition temperature, sandwich corrosion, thermal oxidative stability) were performed as soon as possible after soaking.

5.1 In-plane Shear

Test Description

This test was performed in triplicate for each composite material. The tension test equipment was set up according to ASTM D 3039/D 3039M, and the testing was conducted with normal strain instrumentation in the longitudinal direction, recording continuous or nearly continuous load-normal strain data. Practice runs were performed, as needed, to determine transducer placement, calibration needs, and optimum strain rate. The specimen area was measured at three places in the gauge section and an average of these three measurements was recorded. Next, the specimen was placed in the grips of the testing machine, taking care to align the long axis of the gripped specimen with the test direction. The grips were tightened, and the pressure used on the grips was recorded. After the transducers and strain-recording instrumentation were attached, the load versus strain (or transducer displacement) was recorded. Because no ultimate failure occurred within 5% shear strain, the data were limited to the 5% shear strain mark. Therefore, the 5% shear strain point was considered the maximum shear stress. The shear stress was calculated according to the formula provided in ASTM D 3518/D 3518M.

Test Methodology

Parameters	1 x 10-inch tensile test specimens of each polymer matrix composite, which were tested with extensometer to 5% shear strain.
Type/Number of specimens	PMC 1 and PMC 2 ; three specimens per sheet
Trials per specimen	One
Evaluation Criteria	Compare to unexposed sample results (see deviation below)
Reference Document	ASTM D 3518/D 3518M and ASTM D 3039/D 3039M, MTMS Section 5.4.1

Deviations from, or Interpretation of Test Method

The acceptance criterion was changed to "the average shear strength must exceed 90% of average dry strength", as stated in the MTMS, to allow a more quantitative comparison.

Test Results

The average shear stress and statistical analysis for the polymer matrix composite specimens for each material are listed in Table 7. The raw laboratory data are given in Appendix B.

Table 7. Polymer Matrix Composite Shear Stress Test Results

Polymer Matrix Composite Material / Deicing Fluid	Average Shear Stress, ksi	Difference from Unexposed Sample		
		ksi[1]	STD[2]	%
977-3 Epoxy Resin				
Unexposed	12.42	STD[3] = 0.29		100.0
METSS ADF-2	12.49	0.08	0.28	100.6
Battelle D[3]	12.40	-0.01	-0.03	99.9
METSS RDF-2	12.44	0.03	0.10	100.2
Clariant ® Safeway KF Hot	12.46	0.05	0.17	100.4
Hydro Chemicals AVIFORM® L50	12.39	-0.02	-0.07	99.8
5250-4 BMI Resin				
Unexposed	10.44	STD = 0.20		100.0
METSS ADF-2	10.67	0.24	1.20	102.3
Battelle D[3]	10.59	0.16	0.80	101.5
METSS RDF-2	10.65	0.22	1.10	102.1
Clariant ® Safeway KF Hot	10.37	-0.06	-0.30	99.4
Hydro Chemicals AVIFORM® L50	10.51	0.08	0.40	100.8

1 – Difference between the average deicer result and the average unexposed result.
2 – Value from the (ksi) column divided by the unexposed sample standard deviation; also describes the significance of the data throughout this report..
3 – Standard deviation of the unexposed material, calculated by replicate analysis of the material.

Discussion of the Results

For both PMC materials, there was little to no difference in the specimens exposed to the deicers compared to the unexposed specimens.

5.2 Glass Transition Temperature

Test Description

This test method was used for both the initial tag end testing to determine composite quality, as well as physical testing after exposure to the deicer solutions. In both cases, a 1/8 x 1/8-inch specimen was removed from each polymer matrix composite sheet and dried in an oven at 200°F until the sample weight loss was less than 0.01%. The specimens were placed in a differential scanning calorimeter (DCS) at 10°C per minute ramp rate up to 400°C to determine the onset temperature (glass transition temperature), or the point at which the sample begins to drastically change shape due to thermal expansion. This temperature point was recorded as the glass transition temperature and compared to standard values for tag end testing and unexposed specimen values from physical testing.

Test Methodology

Parameters	1/8 x 1/8-inch specimens from each sheet before (tag end) and after deicer exposure (physical test) are placed in the DSC to determine the onset temperature where the thermal expansion drastically changes.
Type/Number of specimens	PMC 1 and PMC 2; one specimen per sheet
Trials per specimen	One
Evaluation Criteria	Compare to standard values (tag end testing) Compare to unexposed sample results (physical testing)
Reference Document	ASTM E794, MTMS Section 5.4.1

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The glass transition temperatures for each polymer matrix composite specimen are listed in Table 8. The raw laboratory data are provided in Appendix B.

Table 8. Polymer Matrix Composite Glass Transition Temperature Test Results

Polymer Matrix Composite Material / Deicing Fluid	Average Glass Transition Temperature, °C	Difference from Unexposed	
		°C	STD
977-3 Epoxy Resin			
Unexposed – tag end test	270.2	STD = 0.71	
METSS ADF-2	269.7	-0.5	-0.7
Battelle D3	270.2	0.0	0.0
METSS RDF-2	269.9	-0.4	-0.5
Clariant ® Safeway KF Hot	270.9	0.7	0.9
Hydro Chemicals AVIFORM® L50	269.7	-0.6	-0.8
5250-4 BMI Resin			
Unexposed – tag end test	266.0	STD = 0.0	
METSS ADF-2	259.0	-7.0	N/A
Battelle D3	262.5	-3.5	N/A
METSS RDF-2	261.7	-4.4	N/A
Clariant ® Safeway KF Hot	262.7	-3.4	N/A
Hydro Chemicals AVIFORM® L50	261.9	-4.2	N/A

Discussion of the Results

In comparing the deicer-exposed materials to the unexposed materials, all of the deicers had little to no effect on the transition temperatures of the 977-3 epoxy resin material, but decreased the transition temperatures for the 5250-4 BMI Resin material in all cases. In

the “difference from unexposed, °C” column in Table 8, the decrease in temperature from the unexposed for the 5250-4 BMI Resin ranged from 3.4 to 7.0°C.

However, based on *CTC*’s experience in thermophysical properties, the team suspected that the above defined peak values may not be true glass transitions of the materials. To further investigate this theory, the tag end samples were heated a second time. The second heating showed no curve or peaks in the baseline at the temperatures that were previously recorded. By definition, glass transitions are reversible and should have been reproduced in the second heating. The recorded peak values could be due to the relief of mechanical stresses that were introduced into the materials during manufacturing. A better test for determining glass transition temperature might be dynamic mechanical analysis (DMA). The *CTC* team believes that additional testing is required to determine the effect of exposure on the glass transition temperature of the materials evaluated.

5.3 Barcol Indentation Test

Test Description

The test is used to determine the hardness of the polymer matrix composite material before and after exposure to the deicer solutions. The impressor of the Barcol Indentor was placed on a solid surface of the test specimen. The point sleeve was placed on the surface to be tested, and the legs were set on a solid material of the same thickness, ensuring that the impressor was perpendicular to the surface being tested. Uniform and increasing force was applied to the instrument until the dial indication reached a maximum. The Barcol hardness number then was recorded from the dial. This procedure was repeated five times on the same specimen, and the results were averaged.

Test Methodology

Parameters	1 x 2-inch specimen from each polymer matrix composite sheet/hardness measurements with Barcol indentor
Type/Number of specimens	PMC 1 and PMC 2; one per sheet
Trials per specimen	Five
Evaluation Criteria	Compare to unexposed sample results
Reference Document	ASTM D 2583, MTMS Section 5.4.1

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The average Barcol hardness for each polymer matrix composite specimen is listed in Table 9 as well as the difference calculated between the specimens exposed to the deicers and the unexposed specimens. The standard deviation of the difference is also presented

in the table, in order to determine the significance of the difference in the data. The raw laboratory data are located in Appendix B.

Table 9. Polymer Matrix Composite Barcol Hardness Test Results

Polymer Matrix Composite Material / Deicing Fluid	Average Barcol Indentation Hardness, Barcol reading	Difference from Unexposed Average	
		Barcol Hardness Units	STD
977-3 Epoxy Resin			
Unexposed	82.0	STD = 0.28	
METSS ADF-2	81.8	-0.2	-0.7
Battelle D^3	80.4	-1.6	-5.7
METSS RDF-2	81.8	0.2	0.7
Clariant® Safeway KF Hot	81.7	0.3	1.1
Hydro Chemicals AVIFORM® L50	81.3	-0.7	-2.5
5250-4 BMI Resin –			
Unexposed	82.7	STD = 0.14	
METSS ADF-2	81.8	-0.9	-6.4
Battelle D^3	82.2	-0.5	-3.6
METSS RDF-2	81.7	-1.0	-7.1
Clariant® Safeway KF Hot	82.8	0.1	0.7
Hydro Chemicals AVIFORM® L50	82.5	0.2	1.4

Discussion of the Results

As with the glass transition temperature results, the Barcol Hardness of the 5250-4 BMI Resin was affected more by the deicers than the 977-3 epoxy resin. For the 977-3 epoxy resin composite, all final hardness readings were within the range of the unexposed composite. All deicer Barcol Hardness readings for the 5250-4 BMI resin, with the exception of the Clariant® Safeway KF Hot deicer, were less than the range of the unexposed material. The significance of these results is located in the last column of Table 9. If these data are viewed with the standard two- to three-σ difference as being considered statistically significant, the only significant difference for the 977-3 epoxy resin was the sample exposed to Battelle D3. However, for the 5250-4 BMI resin material, METSS ADF-2, METSS RDF-2, and Battelle D3 all showed differences larger than 3 σ from the unexposed material.

5.4 Sandwich Corrosion

Test Description

The Humidity Test Cabinet was configured as specified by ASTM D1748. The test specimens were prepared by constructing a sandwich of: 1) a 2 x 4-inch sample of 2024-T3 aluminum; 2) a 1 x 3-inch piece of filter paper saturated with deicer fluid as the middle layer; and 3) a 2 x 4-inch section of polymer matrix composite material. All aluminum specimens were thoroughly cleaned to remove any oils or surface contaminants. The sandwich was secured together with nylon bolts, and the specimens were placed in a 100°C oven for eight hours. Next, the specimens were removed from the oven and placed in the humidity chamber at 100°F with 95-100% humidity for 16 hours. This cycle was repeated for a total of five days. At the end of the fifth day, the specimens were left in the humidity chamber for an additional 48 hours. When the sandwiches were removed from the chamber, the bolts were broken, the panels were cleaned, and the filter paper was discarded. Both the aluminum and polymer matrix composite portions of the sandwich were examined with a stereomicroscope to determine the severity of corrosion (see scale located in ASTM F1110-90) or discoloration.

Test Methodology

Parameters	Sandwich specimens consisting of 2024-T3 aluminum, filter paper saturated with deicer, and polymer matrix composite specimens/placed in 100°C oven, then humidity chamber set at 100°F/95-100% humidity
Type/Number of specimens	PMC 1 and PMC 2; two per sheet
Trials per specimen	One
Evaluation Criteria	Compare to control specimens exposed to deionized water
Reference Document	ASTM F1110-90, ASTM D1748, MTMS Section 5.4.1

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The material condition for each polymer matrix composite and aluminum panel after exposure to each deicer, as described above, are listed in Table 10. The raw laboratory data are provided in Appendix B. Graphics to show examples of the poor performers can be viewed in Appendix B1.

Table 10. Polymer Matrix Composite Sandwich Corrosion Test Results

Polymer Matrix Composite Material / Deicing Fluid	Material Condition	
	Aluminum[1]	Composite[2]
977-3 Epoxy Resin		
Deionized Water	0-1	0
METSS ADF-2	2-3	0
Battelle D[3]	1	0
METSS RDF-2	4	2-3
Clariant ® Safeway KF Hot	2	0
Hydro Chemicals AVIFORM® L50	0-1	0-1
5250-4 BMI Resin		
Deionized Water	0 [3]	0-1
METSS ADF-2	1-3	0-1
Battelle D[3]	0-1	0-1
METSS RDF-2	3-4	3-4
Clariant ® Safeway KF Hot	2	0
Hydro Chemicals AVIFORM® L50	0-2	0

1 – ASTM F1110 Corrosion Severity Rating System

- 0 = No visible corrosion (none)
- 1 = Very slight corrosion or discoloration (up to 5% of the surface area corroded)
- 2 = Slight corrosion (5-10%)
- 3 = Moderate corrosion (10-25%)
- 4 = Extensive corrosion or pitting (>25%).

2 – general visual inspection of the pitting of the graphite based on the following ratings

- 0 = No visible pitting (none)
- 1 = Very slight pitting (up to 5% of the surface area)
- 2 = Slight pitting (5-10%)
- 3 = Moderate pitting (10-25%)
- 4 = Extensive pitting (>25%).

3 – One of the two panels exposed to deionized water was corroded to a level 4 (>25% pitting). This could be due to cross-contamination issues. Therefore, this value was disregarded for this evaluation.

Discussion of the Results

With reference to the 977-3 epoxy resin, all deicers corroded the aluminum more than the deionized water, except the D[3] and the Hydro Chemicals AVIFORM® L50. However, the 977-3 composite exhibited more pitting after being exposed to the Hydro Chemicals AVIFORM® L50 and the METSS RDF-2.

For the 5250-4 BMI resin, the RDF-2 caused the most corrosion of the aluminum, as well as the greatest pitting of the composite. All other deicers showed some level of aluminum corrosion, and the METSS ADF-2 and Battelle D[3] showed an effect on the composite as well.

5.5 Thermal Oxidative Stability

Test Description

Thermal oxidative stability testing was performed on ten 1 x 1-inch samples of each composite for each deicer fluid exposure. The specimens were cleaned with Scotchbrite® pads and soapy water and then were submerged in an ultrasonic bath (water). The surface area of both sides of each specimen was measured, and each specimen was weighed to the nearest 0.1 milligram. The specimens then were placed in a vacuum oven at 200°F for at least 24 hours. A small sample set was weighed, placed back in the oven until the next day, and reweighed. This process was continued until less than 0.01% weight loss was achieved. Once achieved, a final weight for each specimen was recorded as the "dry weights." Next, the specimens were placed in a convection oven and were covered on an oven rack with a fiberglass breather cloth. The specimens were lightly covered with an additional layer of fiberglass breather cloth. The oven damper was positioned to "mostly closed" (not air tight), and the oven was heated to 400°F at a rate of 10°F per minute. The specimens were heated at the maximum temperature for 100 hours. After 100 hours, the oven temperature was lowered to slightly above room temperature. The specimens were stored in a desiccator until they cooled to room temperature. The specimens were weighed, and this value was recorded as the final weight. The final weight was subtracted from the "dry weight" to determine the weight loss due to thermal exposure. The weight loss per surface area (milligram per squared centimeter) was calculated by dividing the weight loss by the specimen surface area.

Test Methodology

Parameters	1 x 1-inch polymer matrix composite specimens exposed to deicer fluids, then heated in a convection oven at a ramp rate of 10°F per minute to the maximum temperature for the material
Type/Number of specimens	PMC 1 and PMC 2; ten specimens per composite per deicer fluid
Trials per specimen	One
Evaluation Criteria	Compare the weight loss per surface area to control specimens exposed to deionized water
Reference Document	MTMS 5.4.1

Deviations from, or Interpretation of Test Method

There were no deviations from the testing procedure.

Test Results

The weight loss values for each polymer matrix composite specimen after exposure to each deicer, as described above, are listed in Table 11. The raw laboratory data are listed in Appendix B.

Table 11. Polymer Matrix Composite Thermal Oxidative Stability Test Results

Polymer Matrix Composite Material / Deicing Fluid	Average Weight Loss/(Gain) due to Thermal Exposure, %	Variance from DI Water Control		Average Weight Loss/(Gain) per Surface Area, mg/cm^2	Variance from DI Water Control	
		Weight Loss/(Gain), %	STD		Weight Loss/(Gain), mg/cm^2	STD
977-3 Epoxy Resin						
Deionized Water	0.45	STD = 0.063		0.34	STD = 0.05	
METSS ADF-2	0.47	0.02	0.32	0.29	(0.05)	(1.00)
Battelle D^3	0.50	0.05	0.79	0.38	0.04	0.80
METSS RDF-2	0.41	(0.04)	(0.63)	0.31	(0.03)	(0.60)
Clariant ® Safeway KF Hot	0.49	0.04	0.63	0.37	0.03	0.60
Hydro Chemicals AVIFORM® L50	0.46	0.01	0.16	0.35	0.01	0.20
5250-4 BMI Resin						
Deionized Water	(0.13)	STD = 0.064		(0.14)	STD = 0.076	
METSS ADF-2	(0.20)	(0.07)	(1.09)	(0.24)	(0.10)	(1.32)
Battelle D^3	0.47	0.60	9.38	0.52	0.66	8.68
METSS RDF-2	(0.51)	(0.09)	(1.41)	(0.17)	(0.03)	(0.39)
Clariant ® Safeway KF Hot	(0.19)	(0.06)	(0.94)	(0.22)	(0.08)	(1.05)
Hydro Chemicals AVIFORM® L50	(0.20)	(0.07)	(1.09)	(0.21)	(0.07)	(0.92)

Discussion of the Results

All of the weight loss per surface area results for the 977-3 epoxy resin show that the deicers had little effect on the composite. The "STD" was less than, or equal to one σ for the calculated values.

For the 5250-4 BMI resin, all deicers, as well as the deionized water, caused a weight gain after thermal exposure except the Battelle D^3. However, visual examinations of all samples compared to untested portions of sample material showed no signs of oxidation, heat damage, etc. Also, all of the statistical analysis data indicate that the deicer-exposed results vary from the control by less than two σ, showing that the variance is not significant, except for the specimens exposed to Battelle D^3.

5.6 Percent Weight Gain

Test Description

After the initial preparation procedure outlined in Section 5.0, each specimen was weighed to determine the final weight after soaking in deicer fluid (or deionized water).

The “dry” weight (measured before the soak) was subtracted from the final weight, divided by the dry weight, and then multiplied by 100 to determine the percent weight gain.

Test Methodology

Parameters	All samples required for polymer matrix composite tests soaked in the various deicer fluids or DI water control
Type/Number of specimens	PMC 1 and PMC 2; test specimens for each PMC test method that are exposed to deicer fluid according to the Initial Composite Preparation Procedure
Trials per specimen	One
Evaluation Criteria	Compare to control specimens exposed to deionized water
Reference Document	MTMS 5.4.1

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The percent weight gain for each polymer matrix composite after exposure to each deicer and deionized water, as described above, are listed in Figure 1. The raw laboratory data are given in Appendix B.

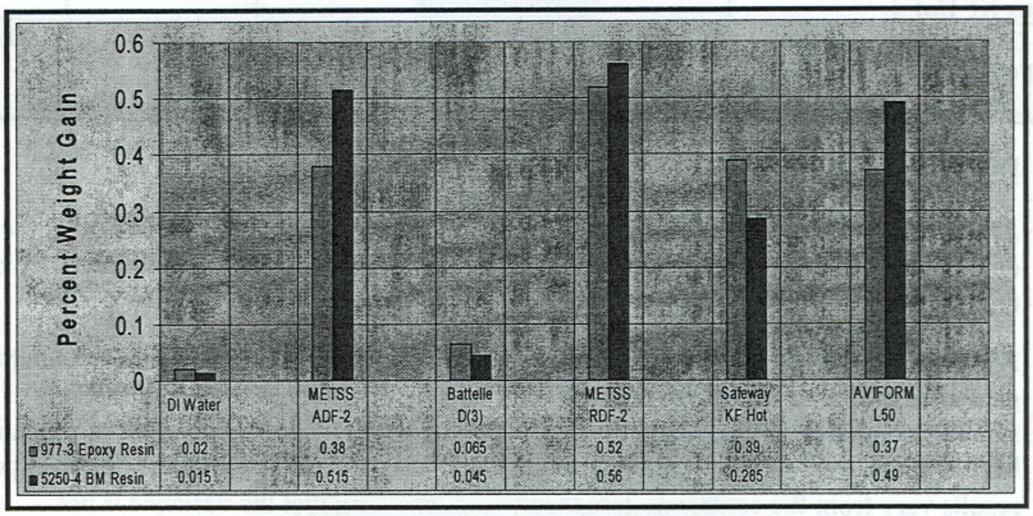


Figure 1. Polymer Matrix Composite Weight Gain Test Results

Discussion of the Results

In general, the weight gain after exposure to deicers was less than one percent for both composites, but was greater than the weight gain from deionized water. For the aircraft

deicers, the METSS ADF-2 had the largest weight gain for both composites. For the runway deicers, METSS RDF-2 exhibited the largest weight gain.

6.0 ELASTOMERIC MATERIALS

Testing for Elastomeric materials included the following:

1. Shore A hardness
2. Percent volume swell
3. Peel strength and percent cohesive failure
4. Ultimate Tensile Strength and Percent Elongation
5. 100% and 300% modulus.

Initial Specimen Preparation Procedure

Sealant materials were assembled within *CTC*'s Environmental Technology Facility laboratory according to manufacturer's recommendations, while the elastomers were received as sheets. The appropriate sample sizes then were cut from the sealant and elastomer sheets.

To prepare the materials for testing (except percent volume swell testing), the nitrile and neoprene materials were immersed in the deicing fluids for eight hours at room temperature then removed from the deicer for 16 hours at room temperature, with this cycle repeated five times. The sealant materials were immersed in the deicing fluids for four hours at room temperature, then removed for 20 hours, and this cycle was also repeated five times. All tests were performed on an unexposed set as well as the exposed material.

Due to the relative costs of the sealant materials, it is important to note that AFRL directed *CTC* not to purchase the fluorosilicone sealant specified in the MTMS. All other sealants specified in the MTMS were included in this material compatibility testing.

Where available, results of the sealant compound testing were compared to the sealant compound specifications. The numbers of the specifications are located in Table 12 and the specifications are included in Appendix C1.

Table 12. Sealant Specifications

Sealant Name	Specification Number
Polysulfide – PRC DeSoto PR 1422	AMS-S-8802
High Temperature Polysulfide – PRC DeSoto PR 1750	AMS-3276C
Corrosion-inhibiting – PRC DeSoto PS-870	MIL-PRF-81733 Type D
Polythioether – PRC DeSoto PS 1826	AMS-3277B

6.1 Shore A Hardness

Test Description

Shore A Hardness measurements were conducted with a hand-held Shore Type A Durometer. The Durometer calibration was verified before beginning measurements by testing a 60-duro test block. The Durometer was placed on the specimen and pressed firmly until the base rested on the sample. The hardness values were read from the gauge on the front of the Durometer. This test was repeated three times, and the values were averaged to report a single hardness result (HA) for each specimen.

Test Methodology

Parameters	Approximately 1 x 3-inch nitrile, neoprene, and sealant samples after exposure to the above soaking cycle.
Type/Number of specimens	EL 1, EL 2, SL 1, SL 2, SL 3, and SL 4; one
Trials per specimen	Three
Evaluation Criteria	Compare to the unexposed sample.
Reference Document	ASTM G-D2240, MTMS 5.4.2

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The average Shore A Hardness results and statistical analysis for the elastomeric materials are provided in Table 13. The raw laboratory data are included in Appendix C.

Table 13. Elastomeric Materials Hardness Test Results

Elastomer Material / Deicing Fluid	Average Shore A Hardness HA	Difference from Unexposed	
		HA	STD
Nitrile Sheet			
Unexposed	50.7	STD = 0.58	
METSS ADF-2	51.0	0.3	0.5
Battelle D^3	51.0	0.3	0.5
METSS RDF-2	50.3	-0.4	-0.7
Clariant ® Safeway KF Hot	50.0	-0.7	-1.2
Hydro Chemicals AVIFORM® L50	50.3	-0.4	-0.7

Table 13. Elastomeric Materials Hardness Test Results (Continued)

Elastomer Material / Deicing Fluid	Average Shore A Hardness HA	Difference from Unexposed	
		HA	STD
Neoprene Sheet			
Unexposed	56.0	STD = 0.0	
METSS ADF-2	56.0	0.0	NA
Battelle D³	56.3	0.3	NA
METSS RDF-2	55.7	-0.3	NA
Clariant ® Safeway KF Hot	56.0	0.0	NA
Hydro Chemicals AVIFORM® L50	55.3	-0.7	NA
Polysulfide Sealant – PRC DeSoto PR 1422			
Unexposed	52.0	STD = 1.73	
METSS ADF-2	51.3	-0.7	-0.4
Battelle D³	49.0	-3.0	-1.7
METSS RDF-2	52.0	0.0	0.0
Clariant ® Safeway KF Hot	53.7	1.7	1.0
Hydro Chemicals AVIFORM® L50	54.3	2.3	1.3
High Temperature Polysulfide Sealant – PRC DeSoto PR 1750			
Unexposed	51.0	STD = 1.00	
METSS ADF-2	50.7	-0.3	-0.3
Battelle D³	50.7	-0.3	-0.3
METSS RDF-2	51.0	0.0	0.0
Clariant ® Safeway KF Hot	51.7	0.7	0.7
Hydro Chemicals AVIFORM® L50	51.7	0.7	0.7
Corrosion-inhibiting Sealant – PRC DeSoto PS-870			
Unexposed	39.3	STD = 0.58	
METSS ADF-2	38.7	-0.6	-1.0
Battelle D³	39.3	0.0	0.0
METSS RDF-2	39.3	0.0	0.0
Clariant ® Safeway KF Hot	38.3	-1.0	-1.7
Hydro Chemicals AVIFORM® L50	40.7	1.4	2.4
Polythioether Sealant – PRC DeSoto PS 1826			
Unexposed	54.0	STD = 1.00	
METSS ADF-2	50.0	-4.0	-4.0
Battelle D³	49.7	-4.3	-4.3
METSS RDF-2	30.7	-23.3	-23.3
Clariant ® Safeway KF Hot	33.0	-21.0	-21.0
Hydro Chemicals AVIFORM® L50	48.7	-5.3	-5.3

Discussion of Results

For the nitrile and neoprene sheet material, the hardness results were comparable to the unexposed sample results, which showed that the deicers had little effect on the sheet materials. This was also the case when comparing the final hardness results of the polysulfide, high temperature polysulfide, and corrosion-inhibiting sealants to the unexposed materials. For these three sealants, the only "difference from the unexposed standard deviation" that was greater than 2σ was the corrosion-inhibiting sealant exposed to AVIFORM® L50. However, the polythioether sealant material results were all significantly lower than the hardness value of the unexposed material. This could indicate that the deicers had a negative effect on the polythioether sealant.

Also, when reviewing the data, it was noted that the unexposed samples for each sealant material showed an appreciable gain in hardness from the initial reading to the final reading, which was taken approximately two weeks later. Although the sealant materials were constructed according to manufacturer's recommendations and cured for 14 days prior to testing, it appears that the sealant materials were not completely cured due to the gain in hardness (see the unexposed sample results in Table 14 for reference).

Table 14. Hardness Results for Unexposed Sealant Specimens

Unexposed Sealant	Initial Hardness	Final Hardness	% Difference
Polysulfide	48.7	52.0	6.8
High Temperature Polysulfide	45.0	51.0	13.3
Corrosion-Inhibiting	33.3	39.3	18.0
Polythioether	48.3	54.0	11.7

6.2 Percent Volume Swell

Test Description

This test procedure is not associated with the initial sample preparation as mentioned above. The samples for percent volume swell were weighed on an analytical balance, while the dimensions were measured with calipers. The samples were placed in the deicer solutions for 72 hours at room temperature and then were air-dried. The samples then were reweighed, and the dimensions were re-measured to determine if any swelling or shrinkage of the sample had occurred as a result of exposure to the deicing fluid. Results were reported as a positive or negative percent numerical change from the original sample weight or dimensions.

Test Methodology

Parameters	Approximately 1 x 3-inch nitrile, neoprene, and sealant samples after 72 hours of immersion
Type/Number of specimens	EL 1, EL 2, SL 1, SL 2, SL 3, and SL 4; two
Trials per specimen	One
Evaluation Criteria	Compare the weight gain or loss after deicer exposure to the sealing compound specification, where available. Also, compare exposed sample results to the unexposed results.
Reference Document	MTMS Section 5.4.2

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The average weight gain or loss and average percent volume swell or shrinkage are listed in Table 15. The raw laboratory data can be reviewed in Appendix C.

Table 15. Percent Volume Swell Test Results

Elastomeric Material / Deicing Fluid	**Average Weight Gain/(Loss), %**	**Difference from Weight Gain/(Loss) Unexposed**		**Average Volume Swell/ (Shrinkage), %**	**Difference from Volume Swell/(Shrinkage) Unexposed**	
		%	**STD**		**%**	**STD**
Nitrile Sheet						
Unexposed	0.004	STD = 0.0021		(0.403)	STD = 0.570	
METSS ADF-2	0.993	0.988	471	0.734	1.137	2.00
Battelle D^3	0.138	0.134	63.8	0.482	0.885	1.55
METSS RDF-2	0.267	0.263	125	0.198	0.601	1.05
Clariant® Safeway KF Hot	(0.050)	(0.054)	(25.8)	0.988	1.391	2.44
Hydro Chemicals AVIFORM® L50	(0.009)	(0.013)	(6.14)	0.739	1.142	2.00
Neoprene Sheet						
Unexposed	0.007	STD = 0.0020		0.0	STD = 0.0	
METSS ADF-2	0.318	0.311	156	0.034	0.034	N/A
Battelle D^3	0.114	0.107	53.6	(0.084)	(0.084)	N/A
METSS RDF-2	0.643	0.636	318	0.864	0.864	N/A
Clariant® Safeway KF Hot	(0.089)	(0.096)	(48.0)	0.017	0.017	N/A
Hydro Chemicals AVIFORM® L50	(0.057)	(0.064)	(31.9)	0.0	0.0	N/A

Table 15. Percent Volume Swell Test Results (Continued)

Elastomeric Material / Deicing Fluid	Average Weight Gain/(Loss), %	Difference from Weight Gain/(Loss) Unexposed		Average Volume Swell/ (Shrinkage), %	Difference from Volume Swell/(Shrinkage) Unexposed	
		(%)	(STD)		(%)	(STD)
Polysulfide Sealant – PRC DeSoto PR 1422						
Unexposed	(0.471)	STD = 0.0935		(1.156)	STD = 0.751	
METSS ADF-2	(0.348)	0.123	1.32	(0.675)	0.481	0.64
Battelle D[3]	(0.311)	0.161	1.72	1.571	2.727	3.63
METSS RDF-2	(0.208)	0.271	2.90	(2.550)	(1.394)	(1.86)
Clariant ® Safeway KF Hot	(0.393)	0.079	0.84	(0.618)	0.538	0.72
Hydro Chemicals AVIFORM® L50	(0.418)	0.054	0.58	(2.521)	(1.365)	(1.82)
High Temperature Polysulfide Sealant – PRC DeSoto PR 1750						
Unexposed	(0.335)	STD = 0.0519		(0.298)	STD = 0.708	
METSS ADF-2	(0.262)	0.073	1.41	(0.235)	0.063	0.09
Battelle D[3]	(0.212)	0.123	2.37	0.451	0.749	1.06
METSS RDF-2	(0.084)	0.251	4.83	(0.161)	0.137	0.19
Clariant ® Safeway KF Hot	(0.327)	0.008	0.16	0.101	0.399	0.56
Hydro Chemicals AVIFORM® L50	(0.364)	(0.029)	(0.56)	(0.700)	(0.402)	(0.57)
Corrosion-Inhibiting Sealant – PRC DeSoto PS-870						
Unexposed	2.811	STD = 0.2264		(1.438)	STD = 0.008	
METSS ADF-2	0.0589	(2.752)	(12.2)	(2.809)	(1.371)	(171)
Battelle D[3]	(0.336)	(3.147)	(13.9)	(2.868)	(1.430)	(179)
METSS RDF-2	0.320	(2.491)	(11.0)	(2.355)	(0.917)	(115)
Clariant ® Safeway KF Hot	(0.396)	(3.207)	(14.2)	(2.531)	(1.093)	(137)
Hydro Chemicals AVIFORM® L50	(0.473)	(2.338)	(10.3)	(2.218)	(0.780)	(97.5)
Polythioether Sealant – PRC DeSoto PS 1826						
Unexposed	(1.093)	STD = 0.0286		(0.234)	STD = 0.106	
METSS ADF-2	(0.734)	0.359	12.5	(1.040)	(0.806)	(7.60)
Battelle D[3]	(0.659)	0.434	15.2	(0.732)	(0.498)	(4.70)
METSS RDF-2	(0.191)	0.902	31.5	(0.996)	(0.762)	(7.19)
Clariant ® Safeway KF Hot	(1.027)	0.066	2.29	(2.176)	(1.942)	(18.3)
Hydro Chemicals AVIFORM® L50	(0.999)	0.094	3.27	0.664	0.898	8.47

Discussion of the Results

Two of the sealant compound specifications (high temperature polysulfide and polythioether sealants) were supplied with percent volume swell guidelines. The high temperature polysulfide sealant had a specified volume swell of 5-15%. The polythioether specification provided a volume swell of 5-25%. All results for the elastomeric materials were less than the 5% volume change.

For the nitrile sheet material, all volume and weight changes were less than one percent except for exposure to METSS ADF-2, which resulted in an average weight gain of almost exactly 1.0%. The standard deviation results for the difference from the unexposed for weight gain/loss were quite significant, showing a large variance from the unexposed sample. However, the difference from the unexposed for the volume swell/shrinkage portion had standard deviation results of 2σ or less, except for the sample exposed to Clariant ® Safeway KF Hot.

The neoprene sheet data trends appeared to be very similar to those for the nitrile sheet data. The actual weight gain/loss results were all within the range of 0.06-0.65% difference from the unexposed material; however, the calculated standard deviations were relatively large, all exceeding 30σ. Standard deviations of the difference from the volume swell/shrinkage could not be calculated because replicate samples of the unexposed material showed no change in volume.

The polysulfide sealant material, due to the nearly 0.5% weight loss in the unexposed sample material, had a difference in standard deviation from the unexposed material of less than 2σ, with the exception of the sample exposed to METSS RDF-2. The volume swell/shrinkage unexposed sample displayed a shrinkage of 1.2% over the test time. In combination with the weight loss, it appears that this sealant may not have been fully cured at the time of testing. The only sample to have a volume swell was the sealant exposed to Battelle D^3, which was also the only sample to have a standard deviation of greater than 2σ for the difference from the unexposed material.

The high temperature polysulfide sealant unexposed sample exhibited a weight loss and volume shrinkage of approximately 0.3%, in each case. Again, under-curing may be the reason for this change. When reviewing the samples exposed to the deicers, all samples showed a weight loss, with METSS RDF-2 samples changing the least from their initial values, but having the most significance in standard deviation of the difference from the unexposed material. All samples had a volume shrinkage except those exposed to Battelle D^3 and Clariant ® Safeway KF Hot, but through statistical analyses, these changes were not considered significant.

The unexposed samples of corrosion-inhibiting sealant material showed an average weight gain of 2.8%, as well as a volume shrinkage of over 1.4%. All of the exposed samples showed much less weight gain/loss in comparison with the unexposed sample, which is evident from the statistical analyses. None of the weight gain/loss standard deviations of the differences from the unexposed samples was less then 10σ. This trend

is also true with the volume swell/shrinkage results. All samples had nearly double the amount of shrinkage as the unexposed sample, resulting in standard deviation results near or greater than 100σ.

Finally, for the polythioether sealant samples, all samples lost weight, with the unexposed material having the greatest weight loss of 1.09%. As with previous sealants, this change in weight of the unexposed material caused the standard deviation of the difference for unexposed values to be quite large for materials that demonstrated much less weight change than the unexposed sample. The samples with the lowest difference in units of standard deviation, Clariant ® Safeway KF Hot and AVIFORM® L50, had the higher percent weight losses. For the volume swell/shrinkage results, the unexposed material had a 0.2% shrinkage over the test time, which was a smaller change than any of the sample materials. All of the differences from unexposed standard deviation results are considered significant, ranging from approximately 4 to 18σ.

6.3 Peel Strength and Percent Cohesive Failure Test

Test Description

This test method applies to the sealant materials only – the nitrile and neoprene sheets were not tested. The sealants were prepared according to the manufacturer's instructions, sandwiching the material between the 2.75 inch x 5 inch pieces of aluminum sheet (4045 aluminum alloy, sulfuric acid anodized, primed with MIL-PRF-23377 and coated with MIL-C-85285 topcoat) and wire mesh. After curing the specimens, one of two identical samples was immersed in deicing fluid according to the initial preparation procedure listed above; the other sample served as the baseline. After the exposure time specified in the initial preparation, the specimens remained in the respective deicer for an additional day at standard conditions. The peel strength test was conducted within five minutes after removing the specimen from the deicer fluid.

To prepare the test specimens for the peel strength test, two one-inch wide strips were cut through the wire mesh and sealing compound to the metal surface of the test panel, and the cuts were extended the full length of the wire mesh. The test specimens then were installed in a tensile test machine. The upper jaw was clamped to the test panels and the lower jaw held the wire mesh. The specimens were stripped back at an angle of 180° to the metal panel at a jaw separation rate of two inches per minute (see Figures 2 and 3). During the peel strength testing, three cuts were made through the sealing compound to the metal panel for some of the samples in an attempt to promote adhesive failure. The cuts were made at approximately one-inch intervals.

The test specimens were prepared by *CTC* and tested at another laboratory, the Anti-Icing Materials International Laboratory (AMIL), in Quebec, Canada, which has extensive experience in testing deicing fluids.

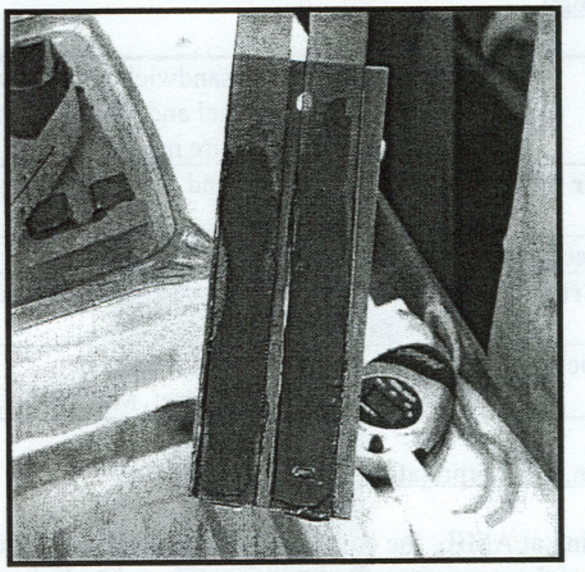


Figure 2. Peel Strength Specimen after Immersion

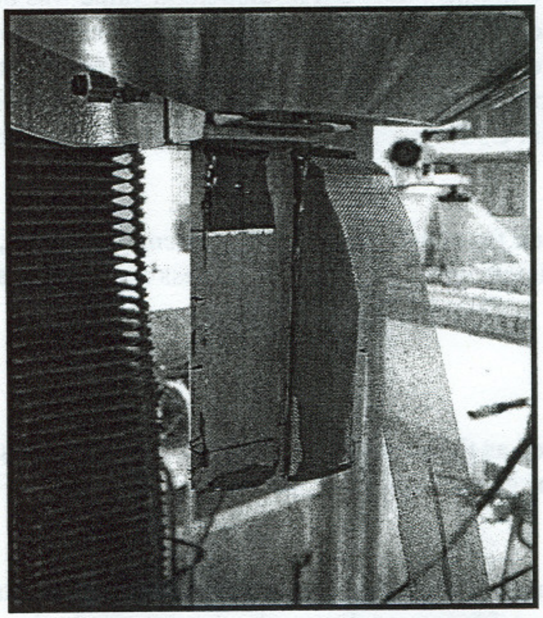


Figure 3. Peel Strength Specimen Loaded into Tensile Machine

Test Methodology

Parameters	Sealant materials sandwiched between a coated aluminum panel and wire mesh; the panel and mesh are clamped into a tensile test machine and the wire mesh is pulled away at 180° angle
Type/Number of specimens	SL 1, SL 2, SL 3, and SL 4; two per sealant
Trials per specimen	One
Evaluation Criteria	Compare to unexposed specimen results and sealing compound specification.
Reference Document	Peel strength: SAE AS 5127/1 Percent cohesive failure: MTMS 5.4.2.3.4c.

Deviations from, or Interpretation of Test Method

During the testing at AMIL, the cuts to promote adhesive failure were performed as needed. Some of the specimens (high temperature polysulfide sealant and the polysulfide sealant) already displayed adhesive failure, so the cutting was unnecessary. For the samples with adhesive failures, the peak peel strength value was obtained from the end of the test as the specimen detached from the plate. This collection of data does not correspond with the requirement in AS5127/1, where the peel strength is defined as the average of the peak loads during cohesive failure (these samples did not display cohesive failure). See Appendix C3 for photos of samples displaying adhesive failure and cohesive failure.

Due to the method used for constructing the peel strength samples, the sealant portion of the sample was not dimensionally uniform (thickness and width), as is required in AS5127/1.

Test Results

The results are reported as the numerical average of the peak loads during cohesive failure. Failure of the sealant compound to the wire mesh was not included in the peel strength values.

Percent cohesive failure is simply a visual inspection of the peel strength panels after testing. A percentage rating was applied to the degree of cohesive failure between the sealant and the paint system, as well as between the paint system and the aluminum panel. The average data is reported in Table 16. The raw data from AMIL are provided in Appendix C2.

Discussion of the Results

For the polysulfide material, the unexposed samples demonstrated 100% adhesive failure before a peak load could be determined. Therefore, no point of reference for comparison exists for the samples that were exposed to the deicers. The construction of the samples

may account for these failures. The sealant material may not have been fully cured prior to testing, as seen with the results of the hardness evaluation (Section 6.1).

The deicer-exposed high temperature polysulfide sealant samples had peel strength results comparable to the range of the unexposed material sample results, with the difference from the unexposed value being between 0.13 and 2.1 σ. Two groups of samples, those exposed to METSS RDF-2 and Clariant ® Safeway KF Hot, had results higher than the unexposed sample range, which indicated no negative effect from exposure to the deicers. The samples exposed to AVIFORM ® L50 showed a decrease in peel strength when compared to the unexposed materials. The AVIFORM ® L50 and METSS ADF-2 peel strength results were less than the sealant specification minimum peel strength of 3,580 N/m.

The corrosion-inhibiting sealant had cohesive failure percentages greater than the unexposed samples, with the exception of the samples exposed to METSS RDF-2. The corresponding peel strength samples were comparable to the unexposed samples, except for the samples exposed to AVIFORM® L50 (4σ difference as compared to less than 1.3 σ for the rest of the samples). In fact, all deicer-exposed samples had peel strength values within or greater than the range of the unexposed samples. This indicates that deicer exposure did not affect the peel strength of the corrosion-inhibiting sealant material.

Table 16. Elastomeric Peel Strength and Percent Cohesive Failure Test Results

Elastomeric Material / Deicing Fluid	Average Peel Strength, N/m	Difference from Unexposed Samples		Average Percent Cohesive Failure, %[1]
		Peel Strength	STD	
Polysulfide Sealant – PRC DeSoto PR 1422				
Unexposed	NA[2]	STD = N/A		0
METSS ADF-2	3,840	N/A	N/A	0
Battelle D[3]	NA[2]	N/A	N/A	0
METSS RDF-2	NA[2]	N/A	N/A	0
Clariant ® Safeway KF Hot	7,700	N/A	N/A	0
Hydro Chemicals AVIFORM® L50	4,110	N/A	N/A	0
High Temperature Polysulfide Sealant – PRC DeSoto PR 1750				
Unexposed	3,700	STD = 445.5		0
METSS ADF-2	3,430[3]	-270	-0.61	0
Battelle D[3]	3,760	60	0.13	0
METSS RDF-2	4,330	630	1.41	0
Clariant ® Safeway KF Hot	4,630	930	2.09	0
Hydro Chemicals AVIFORM® L50	3,270	-430	-0.97	0
Corrosion-Inhibiting Sealant – PRC DeSoto PS-870				
Unexposed	10,080	STD = 473.1		34
METSS ADF-2	9,720	-360	-0.76	44
Battelle D[3]	10,200	120	0.25	41
METSS RDF-2	9,760	-320	-0.68	19
Clariant ® Safeway KF Hot	10,670	590	1.25	54
Hydro Chemicals AVIFORM® L50	11,970	1890	3.99	63
Polythioether Sealant – PRC DeSoto PS 1826				
Unexposed	8,540	STD = 166.9		39
METSS ADF-2	10,320	1780	10.7	42
Battelle D[3]	12,760	4220	25.3	28
METSS RDF-2	10,240	1700	10.2	77
Clariant ® Safeway KF Hot	13,270	4730	28.3	50
Hydro Chemicals AVIFORM® L50	9,490	950	5.69	72

1 – See Appendix C2 for example photos of adhesive and cohesive failures.
2 – Peel strength could not be calculated because samples demonstrated 100% adhesive failure before a maximum peak load could be determined.
3 - Only one sample could be measured – the second sample demonstrated 100% adhesive failure.

The polythioether cohesive failure results were similar to one another, with deicer percent cohesive failure values greater than the unexposed samples, with one exception; the Battelle D^3-exposed samples. All the peel strength values for the polythioether material were greater than the unexposed samples.

According to the sealant specifications, located in Appendix C1, all sealant materials are to exhibit a peel strength result greater than 3,580 N/m. All samples of the polysulfide sealant, corrosion-inhibiting sealant, and polythioether sealant met this criterion.

6.4 Ultimate Tensile Strength and Percent Elongation

Test Description

These tests were used to determine the tensile strength of the specimen, in mega-pascals (MPa), and the percent elongation, which is the percent difference of the distance between the benchmarks placed on the specimen before and after the sample is stretched in the tensile tester. First, the specimens were cut to fit into Die C from Figure 2 of ASTM D 412.

The cross-sectional areas of the specimens were determined in units of square inches. Benchmarks were secured to the specimens for percent elongation determination. The specimens then were placed in the grips of the testing machine, using care to adjust the specimen symmetrically to distribute tension uniformly over the cross section. The rate of grip separation was set to 20 ± 2 inches per minute. The force at the time of rupture was recorded, and the elongation measurement was made using an extensometer, which measured and recorded the elongation to the nearest 10%.

Test Methodology

Parameters	All elastomeric materials prepared according to ASTM D 412 then tested in a tensile machine at a grip rate of 20 inches per minute
Type/Number of specimens	EL 1, EL 2, SL 1, SL 2, SL 3, and SL 4; two
Trials per specimen	One
Evaluation Criteria	Compared with the sealing compound specification, when available. Compare to the unexposed specimen if necessary.
Reference Document	SAE AS5127/1 and ASTM D 412-98a, MTMS Section 5.4.2

Deviations from, or Interpretation of Test Method

Although extreme care in sample preparation was taken, due to the method of construction of the sealant materials (polysulfides, corrosion-inhibiting, and polythioether), some of the samples were not homogeneous, containing air pockets within the samples. Therefore, the forces at the time of rupture for the sealant materials may be low when compared with the sealing compound specification.

Test Results

The ultimate tensile strength (UTS) was calculated using the force magnitude at rupture (MN) and the cross-sectional area of the unstrained specimen (m^2). The percent elongation was calculated comparing the original distance between the benchmarks to the final distance of the extended specimen. The average results are listed in Table 17, while the raw data from AMIL are included in Appendix C4.

Table 17. Elastomeric Ultimate Tensile Strength and Percent Elongation Test Results

Elastomeric Material / Deicing Fluid	Average Ultimate Tensile Strength, MPa	Difference from UTS Unexposed		Average Percent Elongation, %
		Tensile Strength	STD	
Polysulfide Sealant – PRC DeSoto PR 1422				
Unexposed	3.0	STD = 0.69		0.7
METSS ADF-2	2.7	-0.3	-0.4	0.6
Battelle D^3	3.4	0.4	0.6	1.1
METSS RDF-2	3.2	0.2	0.2	1.4
Clariant ® Safeway KF Hot	3.7	0.7	1.0	0.8
Hydro Chemicals AVIFORM® L50	2.9	-0.1	-0.2	1.9
High Temperature Polysulfide Sealant – PRC DeSoto PR 1750				
Unexposed	3.6	STD = 0.35		1.6
METSS ADF-2	2.3	-1.3	-3.7	0.1
Battelle D^3	3.7	0.2	0.4	1.0
METSS RDF-2	3.2	-0.4	-1.0	0.0
Clariant ® Safeway KF Hot	3.2	-0.4	-1.0	1.6
Hydro Chemicals AVIFORM® L50	2.5	-1.1	-3.0	0.3
Corrosion-Inhibiting Sealant – PRC DeSoto PS 870				
Unexposed	1.4	STD = 0.85		2.9
METSS ADF-2	1.7	0.3	0.4	5.1
Battelle D^3	1.6	0.2	0.2	3.8
METSS RDF-2	2.1	0.7	0.8	7.9
Clariant ® Safeway KF Hot	2.6	1.2	1.4	10.8
Hydro Chemicals AVIFORM® L50	1.3	-(0.2)	-(0.2)	1.6

Table 17. Elastomeric Ultimate Tensile Strength and Percent Elongation Test Results (Continued)

Elastomeric Material / Deicing Fluid	Average Ultimate Tensile Strength, MPa	Difference from UTS Unexposed (Tensile Strength)	Difference from UTS Unexposed (STD)	Average Percent Elongation, %
Polythioether Sealant – PRC DeSoto PS 1826				
Unexposed	1.3	STD = 0.85		0.5
METSS ADF-2	2.6	1.3	1.6	1.8
Battelle D^3	2.5	1.2	1.4	0.0
METSS RDF-2	2.8	1.5	1.8	0.7
Clariant ® Safeway KF Hot	1.7	0.4	0.5	0.0
Hydro Chemicals AVIFORM® L50	1.4	0.1	0.1	0.0
Nitrile Elastomer				
Unexposed	15.0[1]	STD = N/A		10.1
METSS ADF-2	15.6	0.6	N/A	9.9
Battelle D^3	15.4	0.4	N/A	9.4
METSS RDF-2	15.1	0.1	N/A	8.3
Clariant ® Safeway KF Hot	15.9	0.9	N/A	10.6
Hydro Chemicals AVIFORM® L50	16.1	1.1	N/A	10.0
Neoprene Elastomer				
Unexposed	8.0[1]	STD = N/A		12.4
METSS ADF-2	9.2	1.2	N/A	14.0
Battelle D^3	9.7	1.7	N/A	15.0
METSS RDF-2	9.8	1.8	N/A	14.5
Clariant ® Safeway KF Hot	9.5	1.5	N/A	14.2
Hydro Chemicals AVIFORM® L50	9.6	1.6	N/A	14.0

1 – A single unexposed sample was analyzed; standard deviation could not be calculated.

Discussion of the Results

The elongation testing results for the polysulfide sealant show that the METSS ADF-2 and Clariant ®Safeway KF Hot had results similar to the unexposed samples. UTS results show that all deicer-exposed samples performed comparably with the unexposed material, resulting in differences from the unexposed samples of less than or equal to 1σ.

The UTS results for the high temperature polysulfide material show that the samples exposed to Battelle D^3, METSS RDF-2, and Clariant ®Safeway KF Hot were comparable to the unexposed samples. The METSS ADF-2 and Hydro Chemicals AVIFORM® L50 had lower UTS values, showing a deviation from the unexposed samples of 3σ and

greater. All of the percent elongation values were less than the unexposed samples except the Clariant ®Safeway KF Hot, which was equivalent.

The corrosion-inhibiting material exhibited a range of results, both greater than and less than the unexposed values for UTS and elongation. However, the UTS values were essentially equivalent, with 1.35σ being the largest difference from the unexposed sealant samples.

The polythioether sealant results for UTS showed that the Hydro Chemicals AVIFORM® L50 deicer performed the closest to the unexposed material. All exposed materials had greater UTS values than the average of the unexposed samples, although the difference from the unexposed samples, being from 0.1 to 1.8σ, is not considered significant (>2σ).

For the nitrile material, all UTS results were slightly higher than the unexposed value. The percent elongation values were similar to the control, with the exception of METSS RDF-2, which had a slightly lower percent elongation. For the neoprene material, all UTS and percent elongation results were higher than the unexposed material. This indicates that the neoprene material is possibly losing some if its elastic nature when exposed to the deicers.

The sealing compound specifications, listed in Table 12 and located in Appendix C4, listed the minimum UTS values for the polysulfide sealant as 1.4 MPa and 1.7 MPa for the other sealant materials. The UTS values for both the polysulfide and high temperature polysulfide sealant materials exceeded these minimum values. However, for the corrosion-inhibiting sealant, the average of the unexposed samples and the samples exposed to AVIFORM® L50 and Battelle D^3 had UTS values less than the specified minimum. The polythioether sealant had UTS results below the minimum specification for the average of the unexposed sample and the AVIFORM® L50-exposed sample. These results may be lower than the specified minimums due to air pockets formed within the sealant materials during preparation and curing. A visual examination of the post-test samples indicated that a number of the test samples experienced failure at a point in the UTS sample where there was an internal void. The following is a list of materials found to contain a void at the point of rupture (Table 18).

Table 18. UTS Samples Containing a Void at Point of Rupture

Sealant Material	Deicer	Number of Samples Affected (total samples tested)
Polysulfide	METSS ADF-2	2 (of 3)
	Battelle D^3	1 (of 2)
	METSS RDF-2	2 (of 2)
	Clariant® Safeway KF Hot	2 (of 2)
	AVIFORM® L50	2 (of 3)
High Temperature Polysulfide	Unexposed	1 (of 2)
	METSS ADF-2	1 (of 3)
	METSS RDF-2	1 (of 2)
	AVIFORM® L50	1 (of 3)
Corrosion-Inhibiting Sealant	Unexposed	2 (of 2)
	METSS ADF-2	1 (of 2)
	Battelle D^3	1 (of 2)
	METSS RDF-2	1 (of 2)
	Clariant® Safeway KF Hot	1 (of 2)
	AVIFORM® L50	1 (of 2)
Polythioether	METSS ADF-2	2 (of 3)
	Battelle D^3	1 (of 2)
	METSS RDF-2	2 (of 2)
	Clariant® Safeway KF Hot	2 (of 2)
	AVIFORM® L50	2 (of 3)

6.5 100% and 300% Modulus

Test Description

Modulus values were determined for all elastomeric materials utilizing the same Die C-shaped specimen as the UTS and percent elongation measurements. The electronic calibration of the load cell was verified, and then the specimen was placed in the tensile machine. The grip rate was set at 20 ± 2 inches per minute. The tensile machine recorded the force required to stretch the specimen in graphical form. The force for 100% and 300% (if possible) extensions was determined from the load versus extension curves per AMIL's procedure.

Test Methodology

Parameters	All elastomeric materials stretched according to AMIL's procedure
Type/Number of specimens	100% Modulus: EL 1, EL 2, SL 1, SL 2, SL 3, and SL 4 exposed to each deicer and DI water control; two per deicer 300% Modulus: SL 1, SL 2, SL 3, and SL 4 exposed to each deicer and DI water control; two per deicer
Trials per specimen	One
Evaluation Criteria	Compare to DI water exposed control
Reference Document	SAE AS5127/1, MTMS Section 5.4.2

Deviations from, or Interpretation of Test Method

One deviation to the testing method was that some of the samples could not be stretched to 300% without rupture. The force at the furthest point before rupture was calculated and the maximum percentage elongation was listed for the specimen.

Test Results

The results are listed in Table 19, while the raw data from AMIL are provided in Appendix C3.

Table 19. Elastomeric Modulus Test Results

Elastomeric Material / Deicing Fluid	100% Modulus, MPa	300% Modulus, MPa
Polysulfide Sealant – PRC DeSoto PR 1422		
Deionized Water	1.8	NA
METSS ADF-2	1.7	NA
Battelle D³	1.7	2.6 (@ 180%)
METSS RDF-2	1.7	2.6 (@ 180%)
Clariant ® Safeway KF Hot	1.9	2.8 (@ 180%)
Hydro Chemicals AVIFORM® L50	1.8	2.6 (@ 172%)
High Temperature Polysulfide Sealant – PRC DeSoto PR 1750		
Deionized Water	1.8	2.7 (@ 180%)
METSS ADF-2	1.7	NA
Battelle D³	1.8	2.5 (@ 176%)
METSS RDF-2	1.8	2.8 (@ 180%)
Clariant ® Safeway KF Hot	1.8	NA
Hydro Chemicals AVIFORM® L50	1.8	NA
Corrosion-Inhibiting Sealant – PRC DeSoto PS 870		
Deionized Water	0.8	1.2 (@ 200%)
METSS ADF-2	1.0	1.5 (@ 204%)
Battelle D³	1.0	1.3 @ 204%

Table 19. Elastomeric Modulus Test Results (Continued)

Elastomeric Material / Deicing Fluid	100% Modulus, MPa	300% Modulus, MPa
METSS RDF-2	1.0	1.2 (@ 208%)
Clariant® Safeway KF Hot	0.9	1.4 (@ 204%)
Hydro Chemicals AVIFORM® L50	1.0	1.3 (@ 208%)
Polythioether Sealant – PRC DeSoto PS 1826		
Deionized Water	1.1	2.7 (@ 176%)
METSS ADF-2	1.5	NA
Battelle D^3	1.5	2.4 (@ 176%)
METSS RDF-2	1.3	NA
Clariant® Safeway KF Hot	2.0	NA
Hydro Chemicals AVIFORM® L50	1.5	NA
Nitrile Elastomer		
Deionized Water	1.4	5.8
METSS ADF-2	1.4	5.8
Battelle D^3	1.4	5.9
METSS RDF-2	1.4	5.7
Clariant® Safeway KF Hot	1.4	5.7
Hydro Chemicals AVIFORM® L50	1.4	5.6
Neoprene Elastomer		
Deionized Water	1.7	5.4
METSS ADF-2	1.8	5.5
Battelle D^3	1.7	5.4
METSS RDF-2	1.7	5.4
Clariant® Safeway KF Hot	1.8	5.7
Hydro Chemicals AVIFORM® L50	1.7	5.6

NA = Not applicable - the complete test was not performed on this material due to premature sample rupture.

Discussion of the Results

The 100% modulus values were similar to the unexposed samples for the polysulfide and high temperature polysulfide sealants. However, these samples could not achieve 300% elongation, so the tensile strength was measured at approximately 180%.

For the corrosion inhibiting sealant, 300% elongation also could not be achieved, so tensile measurements were taken at 200%. All results are slightly higher than the control, but Battelle D^3, METSS RDF-2, and Hydro Chemicals AVIFORM® L50 results may be considered comparable to those for the unexposed samples.

Again, for the polythioether material, 300% modulus could not be achieved, so sample analysis of the deionized water control and the sample exposed to Battelle D^3 was conducted at 176%, providing comparable results. All results of the 100% modulus testing were greater than those for the unexposed material, with Clariant® Safeway KF Hot being particularly high.

All nitrile sheet and neoprene sheet tensile strength values for 100% and 300% modulus were comparable to the unexposed sample values, indicating that the deicers had very little effect on these materials.

7.0 AIRCRAFT WIRE INSULATION

The aircraft wire insulation was tested by the following procedures:

1. Conductivity – MTMS 5.4.3.3.4 a
2. Immersion Test – SAE AS 4373, Test Method 601 and MTMS 5.4.3.3.4 b
3. Bend test for post immersion cracking sensitivity – SAE AS 4373 Test Method 714 and MTMS 5.4.3.3.4 c
4. Voltage Withstand Test – SAE AS 4373, Test Method 5.10, ASTM 3032, and MTMS 5.4.3.3.4 d
5. Wet Arc Track Propagation Resistance Test – MIL STD 2223, Method 3006 and MTMS 5.4.3.3.4 e.

7.1 Conductivity

Test Description

Conductivity measurements were performed on the deicing fluids and a deionized water blank. The meter was calibrated with the appropriate standard solution, and the conductivity of each deicing fluid was measured three times and averaged. The conductivity cell was thoroughly cleaned between each sample reading by rinsing with hot water, then deionized water until the deionized water conductivity values were achieved.

Test Methodology

Parameters	Conductivity measurements of deicer fluids with digital conductivity meter
Type/Number of specimens	Deicing fluids; three
Trials per specimen	One
Evaluation Criteria	Relative standard deviation of the three results is < 2%
Reference Document	MTMS 5.4.3.3.4 a

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

Table 20. Deicing Fluid Conductivity Results

Deicing Fluids	Conductivity, µS	Standard Deviation
METSS ADF-2	70	0.06 (0.09%)
Battelle D^3	630	1.53 (0.24%)
METSS RDF-2	48,900	153(0.31%)
Clariant ® Safeway KF Hot	244,000	1160(0.48%)
Hydro Chemicals AVIFORM® L50	256,000	577(0.23%)

Discussion of Results

The conductivity of the deicing fluids was measured for reference. As expected, the runway deicers had a higher conductivity because the major constituents of these deicers are salt compounds that generate ionic species in solution.

7.2 Immersion

Test Description

Four 24-inch lengths of each wire type were used for testing, three for immersion and one to serve as a control. The outside diameter of each wire was measured in three places with digital calipers. The wires were submersed in deicing fluid to within six inches of each end with the radius of the bend in the wire being between 14 and 35 times the maximum diameter of the wire being tested. The wires remained in the test solutions for 140 hours at room temperature, and the deicing solutions were stirred in the container daily during the workweek throughout the test period. After 140 hours, the wires were removed from the solutions, washed with water, and dried at room temperature. The diameters of the wires were re-measured, and any physical changes to the insulation were noted. The wires then were placed back into the deicing solutions for an additional 140 hours. Again, after the exposure time, the wires were removed, washed, and dried at room temperature. The diameters were measured once more, and any additional effects of the deicer on the insulation were noted.

Test Methodology

Parameters	Four 24-inch length of each wire type submerged in deicer solution; measure diameter with digital calipers
Type/Number of specimens	AWI 1, AWI 2, AWI 3, and AWI 4; four
Trials per specimen	One
Evaluation Criteria	Compare to unexposed control specimen. Per MIL-W-22759E, not to increase by more than 5%.
Reference Document	SAE AS 4373, Test Method 601, MTMS 5.4.3.3.4 b

Deviations from, or Interpretation of Test Method

The bend in the wire during submersion was greater than the required 14 to 35 times the maximum diameter. The bend was approximately three times greater than the maximum values stated above, due to the placement of the wires in the beaker used to hold the deicing fluids.

Test Results

The Table 21 lists the average change in diameter over two readings for each of the three measuring points. The raw data can be found in Appendix D.

Table 21. Aircraft Wire Insulation Immersion Test Results

Aircraft Wire Insulation / Deicing Fluid	Average Gain in Diameter, %
Teflon®	
METSS ADF-2	0.8
Battelle D[3]	0.2
METSS RDF-2	0.0
Clariant ® Safeway KF Hot	0.0
Hydro Chemicals AVIFORM® L50	0.0
Hybrid Construction	
METSS ADF-2	0.0
Battelle D[3]	0.4
METSS RDF-2	0.6
Clariant ® Safeway KF Hot	0.0
Hydro Chemicals AVIFORM® L50	0.0

Table 21. Aircraft Wire Insulation Immersion Test Results (Continued)

Aircraft Wire Insulation / Deicing Fluid	Average Gain in Diameter, %
Cable-Insulated Twisted Pair	
METSS ADF-2	0.1
Battelle D[3]	0.3
METSS RDF-2	0.7
Clariant ® Safeway KF Hot	0.7
Hydro Chemicals AVIFORM® L50	0.3
Polyimide	
METSS ADF-2	0.5
Battelle D[3]	0.8
METSS RDF-2	0.2
Clariant ® Safeway KF Hot	0.2
Hydro Chemicals AVIFORM® L50	0.6

Discussion of the Results

All deicers had very little effect on the four types of aircraft wire insulation tested. None of the wire diameters exceeded the 5% maximum gain set as the acceptance criterion. In fact, all deicers caused a less than 1% gain in diameter for all wire types.

7.3 Bend Test for Post Immersion Cracking Sensitivity

Test Description

Following the immersion test, each wire was subjected to the bend test. A one-pound weight was attached to the end of the 20-gauge wire sections with the other end of the wire wound around a 1.27-inch diameter mandrel. (NOTE: For the cable containing two 22-gauge wires, a 1.60-inch diameter mandrel and a two-pound weight were used.) The wire was wound and rewound in the reverse direction. The winding sequence was repeated a second time so that two bends were formed in each direction in the same section of wire. The wire was visually inspected for damage to the insulation.

Test Methodology

Parameters	Four 24-inch lengths of each wire type from the immersion test
Type/Number of specimens	AWI 1, AWI 2, AWI 3, and AWI 4; four
Trials per specimen	One
Evaluation Criteria	No visible damage to the insulation
Reference Document	SAE AS 4373, Test Method 714, MTMS 5.4.3.3.4 c

Deviations from, or Interpretation of Test Method

No digital pictures were taken because there were no changes in the wire insulation.

Test Results

The raw data can be found in Appendix D. No visible damage to any of the aircraft wire insulations was observed after testing. One exception was a single specimen of the three twisted pair wire. The insulation had some thinning at the top outside the immersion area after being exposed to METSS ADF-2.

7.4 Voltage Withstand

Test Description

This test was performed after the immersion and bend tests using the same wire samples. The purpose was to determine the integrity of the insulation following immersion and bend testing. The insulation was stripped off the last inch of wire on both ends, and the ends were twisted together. The wire was soaked in a salt solution (5% sodium chloride and 0.1% Triton X-100 wetting agent) for a minimum of four hours. Using a Hipot tester, voltage was applied between the twisted ends of the conductor and the grounded solution bath. The voltage was increased from 0 to 2200 VAC at a rate of 500 V/s with the peak voltage being applied for one minute.

Test Methodology

Parameters	Four 24-inch lengths of each wire type from the immersion and bend tests
Type/Number of specimens	AWI 1, AWI 2, AWI 3, and AWI 4; four
Trials per specimen	One
Evaluation Criteria	Compare to the unexposed wire
Reference Document	SAE AS 4373, Test Method 510, MTMS 5.4.3.3.4 d

Deviations from, or Interpretation of Test Method

For safety concerns and to avoid an unexpected shutdown of the Hipot tester during the test time, the maximum current was set at 20 mA. The test wires were still exposed to 2200 VAC for one minute, as stated in the test requirements.

Test Results and Discussion of Results

The raw data for this test can be found in Appendix D. The deicers did not have any deleterious effects on any type of aircraft wire. The one exception was for the single twisted pair wire specimen, exposed to METSS ADF-2, which failed the bend test as stated in Section 7.3. After exposure to the salt solution, crystals formed on the exposed wire and the amperage exceeded 20mA.

7.5 Wet Arc Track Propagation Resistance

Test Description

It is important to note that Raytheon Technical Services of Indianapolis, Indiana performed this test. This test was used to assess the ability of the wire insulation to prevent damage in an electrical environment.

Polyimide insulated wiring was the only test wiring insulation known to arc track; therefore, the test was only conducted using the AWI 4. Seven wires, 15 inches long, were cut, and the insulation was stripped from the ends of five of the seven wires for electrical connections (active wires). The two unstripped wires were used as passive wires. Using a blade, a groove was cut around two of the active wires at the midpoint to expose the conductor. The wires were bundled according to the diagram located in MIL-STD-2223, Method 3006 (shown in Figure 4, below). The bundle of wires was placed into the testing apparatus, a Lectromec Wet and Dry Arc Track Resistance Test System, and the deicing fluid was dripped at a rate of 8-10 drops per minute into the grooves previously cut in the two wires. For each deicing fluid, the test was conducted using a 2.0-ohm resistance.

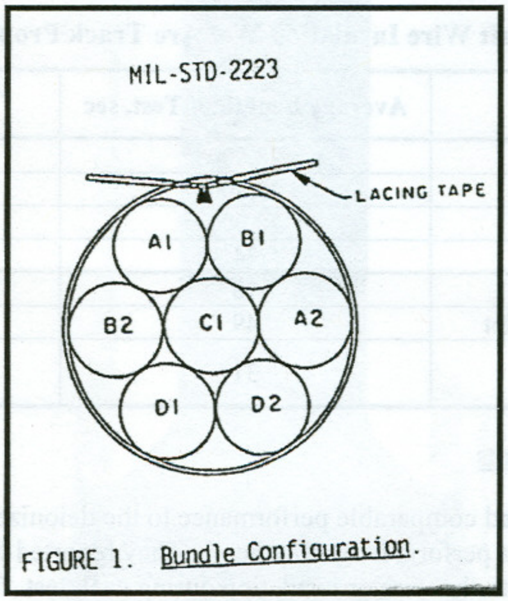


Figure 4. MIL-STD-2223 Wet Arc Track Propagation Wire Configuration

This method initiates an arc by dripping deicer over pre-damaged wires, which creates a conductive path between the wires. Arc-propagation resistance is reported as the length of damage along the pre-damaged wires, as well as the extent of damage to the adjacent, undamaged wires.

Test Methodology

Parameters	Seven 15-inch in length the AWI 4 wire specimen, bundled together; deicing fluid is dripped onto a "damaged" portion of 2 of the wires to generate arc tracking
Type/Number of specimens	AWI 4; three
Trials per specimen	One
Evaluation Criteria	Performs as well as control specimen (deionized water)
Reference Document	MIL-STD-2223, Method 3006, MTMS 5.4.3.3.4 e

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description.

Test Results

The length and extent of damage to each wire was documented, as well as the time elapsed before the damage occurred. The averaged results were calculated from three specimens and are listed in Table 21. The raw data as reported by Raytheon are given in Appendix D1.

Table 22. Aircraft Wire Insulation Wet Arc Track Propagation Test Results

Deicer/Solution	Average Length of Test, sec	Average Damaged Wire Length, in
Deionized Water	28,800	N/A
METSS ADF-2	28,800	N/A
Battelle D^3	28,000	N/A
3% NaCl Solution	34	2.5
METSS RDF-2	18	2.2
Clariant ®Safeway KF Hot	49	2.4
Hydro Chemicals AVIFORM® L50	31	2.1

Discussion of the Results

Both aircraft deicers had comparable performance to the deionized water in the Wet Arc Track Propagation Test performed by Raytheon. They reported that the METSS ADF-2 showed no reaction with the wire or insulation during each test. The Battelle D^3 passed the test by not producing catastrophic arcing during testing; however, the deicer did exhibit electrically conductive characteristics and discolored the exposed wiring.

All three runway deicers performed worse than the deionized water in the wet arc track propagation test. These three fluids generated catastrophic wet arc tracking events nearly identical in time, number of wires damaged, and length of damaged wire as compared to the standard 3% sodium chloride in deionized water solution, which is expected because they are all salt solutions.

8.0 CARBON/CARBON BRAKE FRICTION MATERIALS

The carbon/carbon brake friction materials were tested for Oxidation Resistance as specified in the MTMS, Section 5.5.1.

8.1 Oxidation Resistance

Test Description

This procedure was used to verify the effects of deicing fluids on carbon-carbon composite, aircraft, brake friction materials, specifically to determine the rate and extent of oxidation. The manufacturer of the rotors and stators, Honeywell International, Aircraft Landing Systems, prepared the test samples. Honeywell cut the rotors or stators into 2-inch diameter specimens using a carbide-tipped saw. Ten specimens were cut for each deicing fluid to be tested, with five of the specimens brushed with anti-oxidant penetrant coating and cured. The initial specimen weight, to the nearest mg, and hardness, Shore D durometer, were measured for each specimen. Each set of specimens was subjected to the following steps:

- Immersion in deicing fluid or deionized water (control) for 20 minutes to contaminate the specimens,
- Removal from the solutions and drying at 110°F for 30 minutes,
- Heating in a preheated oven at 1300°F for four hours,
- Immediate removal from the oven and cooling in laboratory ambient air – not actively cooled,
- Heating, again, in the oven at 1300°F for an additional four hours.

After each step listed above, the weight and hardness were measured.

Test Methodology

Parameters	2-inch diameter samples of carbon-carbon brake friction materials immersed in deicer then heated in cycles in a 1300°F oven
Type/Number of specimens	CC 1, CC 2, CC 3, and CC 4; ten samples per deicer solution (five with and five without anti-oxidant coating)
Trials per specimen	One
Evaluation Criteria	Is as oxidation resistant as control specimen (deionized water)
Reference Document	MTMS Section 5.5.1

Deviations from, or Interpretation of Test Method

There were no deviations from the specified test description. Anti-oxidant penetrant coatings varied with each set of carbon-carbon brake material type. CARBENIX 1000 and 2000 received single coats of P-13 antioxidant penetrant, CARBENIX 2110 received a double coat of this material, and CARBENIX 4000 was double-coated with P-13M anti-oxidant penetrant. According to a Honeywell representative, the coating procedures described here for each type of carbon-carbon brake material are the standard application techniques utilized for actual rotors and stators.

Test Results

Table 23 contains the average percent weight loss and average percent hardness loss for all carbon-carbon brake friction materials without anti-oxidant penetrant. These data are also represented in chart format, in Figure 5. The raw data is in Appendix E.

Table 23. Carbon-Carbon Brake Oxidative Resistance Test Results – Uncoated Samples

Carbon-Carbon Brake Friction Material / Deicing Fluid	Average Weight Loss, %	Difference from DI Water Control		Average Hardness Loss, %	Difference from DI Water Control	
		% Weight Loss	STD		% Hardness Loss	STD
CARBENIX 1000						
Deionized Water	47.2	STD = 3.88		84.8	STD = 7.88	
METSS ADF-2	53.4	6.3	1.6	67.6	17.2	2.2
Battelle D^3	62.2	15.0	3.9	56.8	28.0	3.6
METSS RDF-2	56.9	9.7	2.5	13.0	71.8	9.1
Clariant ® Safeway KF Hot	65.7	18.5	4.8	11.4	73.4	9.3
Hydro Chemicals AVIFORM® L50	51.8	4.7	1.2	10.8	74.0	9.4
CARBENIX 2000						
Deionized Water	45.0	STD = 1.96		82.7	STD = 3.98	
METSS ADF-2	48.3	3.3	1.7	84.5	1.8	0.45
Battelle D^3	39.3	-5.7	-2.9	51.1	-31.6	-7.9
METSS RDF-2	55.2	10.3	5.2	11.9	-70.8	-17.8
Clariant ® Safeway KF Hot	56.9	11.3	5.7	25.2	-57.5	-14.4
Hydro Chemicals AVIFORM® L50	45.6	0.6	0.3	32.7	-50.0	-12.6
CARBENIX 2110						
Deionized Water	12.8	STD = 6.84		32.1	STD = 16.79	
METSS ADF-2	35.1	22.2	3.3	65.7	33.6	2.0
Battelle D^3	20.3	7.5	1.1	51.9	19.8	1.2
METSS RDF-2	60.0	47.2	6.9	19.5	-12.7	-0.8
Clariant ® Safeway KF Hot	60.6	47.8	7.0	17.4	-14.8	-0.9
Hydro Chemicals AVIFORM® L50	60.1	47.3	6.9	41.6	9.5	0.6
CARBENIX 4000						
Deionized Water	8.9	STD = 1.09		10.2	STD = 6.44	
METSS ADF-2	22.7	13.8	12.7	14.6	4.4	0.7
Battelle D^3	33.6	24.7	22.6	42.3	32.1	5.0
METSS RDF-2	79.6	70.7	64.9	18.7	8.5	1.3
Clariant ® Safeway KF Hot	57.4	48.5	44.5	18.5	8.3	1.3
Hydro Chemicals AVIFORM® L50	70.1	61.2	56.1	21.2	11.0	1.7

The Carbon-Carbon Brake Oxidative Resistance Results for the samples coated with anti-oxidant penetrant are located in Table 23. These results are also represented graphically in Figure 5.

Table 24. Carbon-Carbon Brake Oxidative Resistance Test Results – Coated Samples

Carbon-Carbon Brake Friction Material / Deicing Fluid	Average Weight Loss, %	Difference from DI Water control		Average Hardness Loss, %	Difference from DI Water Control	
		% Weight Loss	STD		% Hardness Loss	STD
CARBENIX 1000 – coated with Honeywell P-13 anti-oxidant penetrant						
Deionized Water	5.3	STD = 0.29		10.8	STD = 1.32	
METSS ADF-2	6.2	0.8	3.0	15.5	4.6	3.5
Battelle D^3	4.9	0.4	1.4	15.8	4.9	3.7
METSS RDF-2	36.0	30.7	106	49.2	38.3	29.0
Clariant ® Safeway KF Hot	27.7	22.4	77.2	43.3	32.5	24.6
Hydro Chemicals AVIFORM® L50	14.6	9.3	32.1	33.9	23.1	17.5
CARBENIX 2000 – coated with Honeywell P-13 anti-oxidant penetrant						
Deionized Water	10.5	STD = 0.50		32.3	STD = 9.40	
METSS ADF-2	11.7	1.1	2.2	29.1	-3.3	-0.4
Battelle D^3	10.3	0.3	0.6	36.4	4.2	0.4
METSS RDF-2	48.7	38.2	76.3	57.4	25.1	2.7
Clariant ® Safeway KF Hot	54.1	43.6	87.1	64.8	32.5	3.5
Hydro Chemicals AVIFORM® L50	35.5	25.0	50.0	33.2	0.9	0.1
CARBENIX 2110 – coated with Honeywell P-13 anti-oxidant penetrant (double coat)						
Deionized Water	2.9	STD = 1.01		13.5	STD = 10.10	
METSS ADF-2	1.2	1.7	1.7	5.6	-7.0	-0.6
Battelle D^3	2.9	0.0	0.0	6.3	-6.3	-0.5
METSS RDF-2	18.1	15.2	15.1	45.7	33.2	2.8
Clariant ® Safeway KF Hot	40.1	37.3	36.9	40.4	27.8	2.4
Hydro Chemicals AVIFORM® L50	65.4	62.6	62.0	77.7	65.1	5.5
CARBENIX 4000 – coated with Honeywell P-13M anti-oxidant penetrant (double coat)						
Deionized Water	2.2	STD = 0.53		3.8	STD = 4.87	
METSS ADF-2	0.6	1.7	3.1	5.9	3.0	0.6
Battelle D^3	1.7	0.5	1.0	4.9	-0.5	-0.1
METSS RDF-2	0.0	2.7	5.1	1.6	-1.9	-0.4
Clariant ® Safeway KF Hot	1.2	1.0	1.9	3.2	0.3	0.07
Hydro Chemicals AVIFORM® L50	0.1	2.2	4.1	0.0	-6.1	-1.3

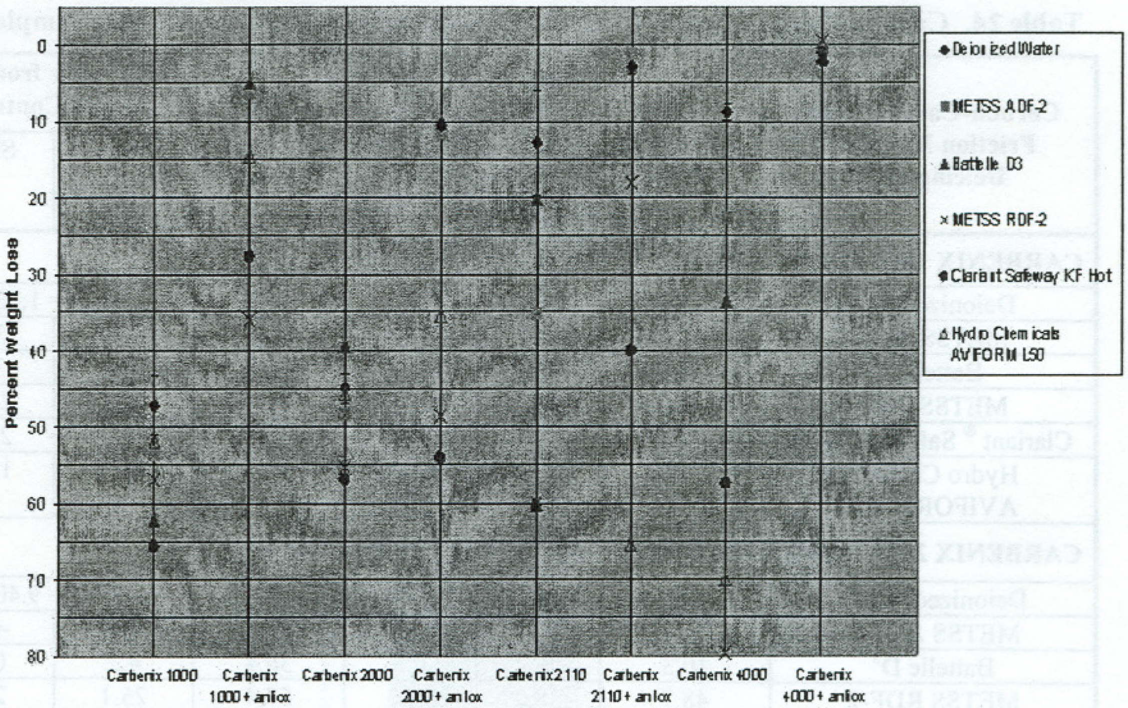


Figure 5. Carbon-Carbon Brake Oxidation Resistance Test Results

Discussion of the Results

The observations regarding the carbon-carbon brake materials can be divided into the two categories: uncoated brake materials and anti-oxidant coated brake materials. First, the uncoated brake materials displayed a definite difference in results between the 1000 and 2000 samples and the 2110 and 4000 samples. The standard deviation of the difference in percent weight loss associated with the 1000 and 2000 samples was greater than 2σ for the samples exposed to Battelle D^3, METSS RDF-2, and Clariant ®Safeway KF Hot for both materials. For these materials, the control (DI water) also showed the highest loss in hardness. The runway deicers (Clariant ®Safeway KF Hot, METSS RDF-2, and Hydro Chemicals AVIFORM® L50) caused the least change in hardness values, but resulted in the largest difference from the control in standard deviation.

For the 2110 and 4000 uncoated samples, all of the exposed samples had percent weight loss values greater than the deionized water control, with the runway deicers having the highest percent weight losses. When comparing the percent hardness loss values, the aircraft deicers caused the highest hardness losses for the 2110 and 4000 specimens. Still, most deviations in the hardness from the control for 2110 and 4000 were low, partly due to the large range of the hardness values for the control.

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In general, the bio-based aircraft deicers caused a significantly greater loss in hardness than the runway deicers for all of the uncoated brake materials.

Concerning the anti-oxidant coated specimens, Honeywell provided some additional information regarding the type and application of the penetrant. The P-13 coating is a mixture of phosphoric acid and metal phosphates and as cured, is a mixture of crystalline and glassy phosphates. A single coat of P-13 was applied to the CARBENIX 1000 and 2000 series materials, and a double coat was applied to the 2110 brake material. The P-13M product consists of the P-13 base formulation with an additional silicone-containing additive. As cured, P-13M is similar to P-13 but with a large component of crystalline silicon phosphates. A double coat of this penetrant was applied to the CARBENIX 4000 series materials. The anti-oxidant coated specimens all behaved similarly when comparing percent weight loss and percent hardness loss except for 4000, which was much less affected by the runway deicers than,the other materials. For all four carbon-carbon brake materials, Battelle D^3 produced weight loss and hardness loss values equivalent to the deionized water control. In all cases except the 4000 series specimens, the runway deicers had significantly higher percent weight losses and hardness losses than the aircraft deicers and the control.

The general conclusions that can be made from these testing results are as follows:

- The uncoated carbon-carbon brake materials had higher percent weight and percent hardness losses than the anti-oxidant coated materials,
- For the uncoated brake materials, the 1000 and 2000 series specimens performed similarly, as did the 2110 and 4000 series,
  -1000 and 2000: weight losses were somewhat comparable; aircraft deicers caused a greater hardness loss than runway deicers,
  -2110 and 4000: roadway deicers had the greatest weight loss and the aircraft deicers showed the largest hardness loss,
- For the anti-oxidant coated brake materials, three of four brake materials had larger percent weight losses and hardness losses when exposed to the runway deicers,
- All anti-oxidant coated 4000 series specimens behaved comparably to the deionized water control in both percent weight loss and percent hardness loss,
- The coating decreased the hardness loss caused by aircraft deicers but increased the hardness loss caused by runway deicers,
- The coated 4000 series material saw the least effect of the deicers in terms of both weight and hardness losses, with no significant changes in hardness at all.

This severe test method for oxidative resistance was developed at Hill Air Force Base (AFB). Although it has been measured that the brakes do experience 1,500-2,000 °F temperatures upon landing, the duration of the heating cycles may not be representative of actual braking conditions. It would be expected that real carbon-carbon brakes would experience a lot less damage; therefore, the test results may not be typical of actual

deicing fluid effects, and the data should be interpreted for each specific material application.

9.0 INFRARED (IR) WINDOW MATERIAL

The infrared window materials were tested for Fourier Transform Infrared Spectrometer (FTIR) Transmission per the MTMS, Section 5.5.2.

9.1 Fourier Transform Infrared (FTIR) Transmission

Test Description

This test was used to determine if the deicing fluids would damage IR window materials by measuring the transmission through the windows before and after exposure to the deicer. Two 1-inch diameter disks were procured for each IR window material. Using an FTIR spectrometer, pre-test measurements were performed on each IR material. The transmission spectra for IR 1 are in the range of 3-5 microns, while IR 2 and IR 3 are in the range of 8-11.5 microns. For each material, pre-test visual examinations were performed. Separate samples were immersed in each deicing fluid for the cycle of four hours immersion and 20 hours drying, for a five-day period. After the last cycle, each sample was washed with deionized water and dried with nitrogen gas. Post-test IR transmission spectra measurements and visual examinations were completed for each IR material.

Test Methodology

Parameters	One-inch diameter disks of IR window materials, immersed in deicers and measured before and after immersion for IR transmission
Type/Number of specimens	IR 1, IR 2, and IR 3; two each
Trials per specimen	One
Acceptance Criteria	Staining or discoloration of material surfaces shall not exceed that which can be cleaned with water, acetone, alcohol, or similar solvents, and transmission loss due to exposure shall not exceed 10%
Reference Document	MTMS Section 5.5.2

Deviations from, or Interpretation of Test Method

There were no deviations from the above test procedure. No post-test photos were taken because there was no staining or discoloration observed on the specimens.

Test Results

The average percent transmission loss of the two specimens per IR window material is presented in Table 24. The table also includes comments concerning any extra

transmission peaks as well as any visual staining, discoloration or clouding of the IR window material. The raw laboratory data are listed in Appendix F.

Table 25. Infrared Windows Transmission Loss Results

IR Window Material / Deicing Fluid	Average Percent Transmission Loss, %	Visual Exam Comments
Aluminum Oxynitride (ALON)		
DI Water	0.0	No staining or discoloration
METSS ADF-2	3.59	No staining or discoloration
Battelle D^3	0.0	No staining or discoloration
METSS RDF-2	0.0	No staining or discoloration
Clariant ® Safeway KF Hot	0.0	No staining or discoloration
Hydro Chemicals AVIFORM® L50	0.0	No staining or discoloration
Sapphire		
DI Water	0.40	No staining or discoloration
METSS ADF-2	32.11	No staining or discoloration
Battelle D^3	9.19	No staining or discoloration
METSS RDF-2	31.53	No staining or discoloration
Clariant ® Safeway KF Hot	29.84	No staining or discoloration
Hydro Chemicals AVIFORM® L50	34.14	No staining or discoloration
Zinc Selenide (ZnSe)		
DI Water	0.37	No staining or discoloration
METSS ADF-2	0.00	No staining or discoloration
Battelle D^3	0.0	No staining or discoloration
METSS RDF-2	0.0	No staining or discoloration
Clariant® Safeway KF Hot	0.46	No staining or discoloration
Hydro Chemicals AVIFORM® L50	7.86	No staining or discoloration

Discussion of the Results

Three IR window materials were tested utilizing FTIR analysis: sapphire window material, zinc selenide, and aluminum oxynitride (ALON). The ALON material showed no change in IR transmittance due to exposure to the deicer materials. The zinc selenide window material showed some loss in transmittance (< 10%) for the Hydro Chemicals AVIFORM® L50 roadway deicer only. The sapphire window material showed significant transmittance losses for all deicer materials except Battelle D^3. The average of the two samples exposed to Battelle D^3 resulted in a transmittance loss of less than ten percent. The average losses in transmittance for the remaining four deicer solutions are comparable to each other. Also, there was no visible staining or discoloration of any of the specimens tested.

10.0 SUMMARY OF RESULTS

10.1 Metallic Materials

Two tests were conducted to determine the compatibility of the alternative deicers with metallic materials. The first, alternate immersion, had test samples of various substrates exposed to deicing fluid for 10 minutes, then air-dried for 50 minutes, with the cycle repeated continuously for two weeks. The purpose of this test was to determine if surface corrosion occurred and if this corrosion was severe enough to cause a change is sample weight. The second test, stress-corrosion cracking susceptibility, used strained specimens manufactured of the same substrates as the alternate immersion samples, exposed to the deicers under the same conditions. This test was designed to determine if the deicers would corrode the substrate materials and cause failure.

All metallic substrate-deicer combinations passed the stress-corrosion cracking test. There were no failures of any of the strained specimens. However, during alternate immersion testing, the AZ91E-T6 cast magnesium alloy was greatly affected by the runway deicers (METSS RDF-2, Clariant® Safeway KF Hot, and Hydro Chemicals AVIFORM® L50), with severe white corrosion covering a large portion of the surface area. The only other substrate material to experience measurable corrosion was the 7075-T6 aluminum alloy. METSS ADF-2 and METSS RDF-2 caused slight weight losses due to filiform corrosion. The deicers had little to no effect on the remaining substrate materials of A286 steel, 4140 steel, and C630 aluminum-bronze alloy.

10.2 Polymer Matrix Composite Materials

Numerous tests were performed on the two polymer matrix composite materials provided by The Boeing Co.: 977-3 epoxy resin and 5250-4 bismaleimide (BMI) resin. These tests included in-plane shear, glass transition temperature, hardness by Barcol indentation, sandwich corrosion, thermal oxidative stability, and percent weight gain. These particular tests were used to determine if exposure to

the deicing fluids would cause a change in the strength, hardness, corrosive, and/or thermal stability properties of the PMC materials.

First, in-plane shear testing results showed that all deicer-exposed samples easily surpassed the listed acceptance criterion of exceeding 90% of the unexposed shear strength. In fact, the largest calculated deviation from the control samples was 1.2σ, which is not considered to be statistically significant.

For the Barcol hardness and glass transition temperature tests, the BMI resin was affected to a larger degree than the 977-3 epoxy resin. The deicer-exposed sample results for the 977-3 hardness and glass transition temperature testing were all within the range of values measured for the unexposed sample material. However, the BMI resin materials exposed to deicers had transition temperatures from 3.4 to 7.0°C lower than the unexposed material, and hardness readings below the unexposed sample range (with the exception of the Clariant® Safeway KF Hot specimens).

This trend also continues with the thermal oxidative stability study, where the 977-3 epoxy resin samples exposed to deicers showed little to no effect when compared to the deionized water-exposed control sample. The BMI material showed a weight gain after exposure (except for the Battelle D^3-exposed specimens) including the deionized water control sample. Still, statistical analysis indicates that the variance of the BMI material was not significant (less than 2σ) except for the samples exposed to Battelle D^3.

The final test, sandwich corrosion, had similar results for the 977-3 epoxy resin and 5250-4 BMI resin materials. Almost all deicers caused some level of corrosion to the aluminum portion of the sandwich, but only METSS RDF-2 and Hydro Chemicals AVIFORM® corroded the 977-3 resin as well. The 5250-4 BMI resin had some level of pitting from exposure to METSS RDF-2, METSS ADF-2, and Battelle D^3.

10.3 Elastomeric Materials

The elastomeric materials were composed of two groups: the sheet materials and the sealants. The sheet materials involved in the testing included nitrile and neoprene, purchased from sheet stock. The sealant materials, which were polysulfide, high temperature polysulfide, corrosion-inhibiting, and polythioether, were purchased in one or two component tubes. The specimens had to be extruded from the tubes and cured for two weeks.

A number of tests were performed on the elastomer materials to determine which properties were affected by exposure to the sealant materials. Testing included hardness, percent volume swell, peel strength (sealants only), ultimate tensile strength and percent elongation, and 100% and 300% modulus.

For the sheet materials, the hardness and percent volume swell results were comparable to the unexposed control results, with the calculated deviations not considered to be statistically significant. For three of the sealants (polysulfide, high temperature polysulfide, and corrosion-inhibiting), the only "difference from the unexposed standard deviation" that was greater than 2σ was the corrosion-inhibiting sealant exposed to AVIFORM® L50. The polythioether sealant material results were all significantly lower than the hardness value of the unexposed material. Also, for all of the sealant materials, the unexposed materials showed an appreciable gain in hardness over the two-week test period. Even though the materials were cured according to manufacturer's recommendations, it appears that the samples may not have been completely cured at the start of the test. This is also the case for the percent volume swell test. For this test, some of the unexposed control samples exhibited shrinkage over the test period. Still, all percent volume swell results were less than the 5-15% and 5-25% volume changes permitted in the sealing compound specifications.

Peel strength testing was only performed on the sealant materials, based on the construction of the test specimens. For the polysulfide sealant material, the unexposed sample demonstrated 100% adhesive failure, so peel strength could not be calculated. This could be the result of sample preparation and cure time issues, as seen with the hardness and percent volume swell testing.

The high temperature polysulfide sealant samples had peel strength results with deviations of 0.13 to 2.1σ from the unexposed material. Only samples exposed to AVIFORM® L50 showed a decrease in peel strength when compared to the unexposed material results. Also, samples exposed to AVIFORM® L50 and METSS ADF-2 had peel strength results less than the sealing compound specification of 3,580 N/m.

All peel strength and cohesive failure results for the corrosion inhibiting sealant samples were comparable to the unexposed samples, except AVIFORM® L50, for which there was a significant statistical difference of 4σ. Exposure of the polythioether sealant to the deicers resulted in peel strength and cohesive failure values greater than the unexposed samples.

UTS results for the deicer-exposed, polysulfide sealants were all comparable to the unexposed material, with a deviation of less than, or equal to 1σ. The results of the high temperature, polysulfide sealant tests showed that samples exposed to METSS ADF-2 and AVIFORM® L50 had lower UTS values than the unexposed samples, resulting in deviations of greater than 3σ. The UTS and elongation results for the corrosion-inhibiting and polythioether sealants were comparable to the unexposed material, as were the results for the nitrile and neoprene sheet materials.

For the 100% modulus testing, most of the elastomeric materials had results comparable to the unexposed samples. 300% modulus could not be achieved for the sealant materials, so the tensile measurements were performed immediately prior to rupture.

10.4 Aircraft Wire Insulation

The deicers had very little effect on any of the insulation materials, with passing results achieved for the immersion, bend, and voltage withstand tests. The results of the Wet Arc Track Propagation Test showed that the aircraft deicers performed similarly to deionized water. However, the runway deicers caused catastrophic wet arc tracking events similar to a 3% sodium chloride solution.

10.5 Carbon-Carbon Brake Materials

The carbon-carbon brake material specimens were cut from actual rotors and stators manufactured by Honeywell. Half of the samples received the standard anti-oxidant coating, with the other half of the samples to be test without coating. The coated samples performed more consistently and comparably to the deionized water controls, with the runway deicers having greater deviations from the control by having higher percent weight and hardness losses. For the uncoated materials, the aircraft deicers demonstrated the largest hardness losses while the runway deicers had the highest percent weight losses.

In summary: 1) for the uncoated brake materials, the 1000 and 2000 series specimens performed similarly, as did the 2110 and 4000 series; 2) for the coated brake materials, three of the four types of brake materials had the largest percent weight losses and hardness losses when exposed to the runway deicers.

10.6 Infrared Window Materials

Three IR window materials were tested utilizing FTIR spectroscopy analysis, namely sapphire window material, zinc selenide, and aluminum oxynitride (ALON). The ALON material showed no change in IR transmittance due to exposure to the deicing materials. The zinc selenide window material showed some loss in transmittance (< 10%) for the Hydro Chemicals AVIFORM® L50 roadway deicer only. The sapphire window material showed significant transmittance losses for all deicing materials except Battelle D^3.

11.0 RECOMMENDATIONS

CTC recommends reviewing the alternative aircraft deicers test data with the appropriate aircraft System Program Office (SPO) to prioritize the results and determine if potential field-testing is warranted. The Air Force, with Environmental Security Technology Certification Program (ESTCP) funding, has already field-tested the Battelle D^3 deicing fluid at the Niagara Falls Air Reserve Station (NFARS) in Niagara Falls, NY. Based on the results of this report, Phase III of this project involved *CTC* and the Air Force

coordinating the field-testing of the METSS ADF-2 deicing fluid in February 2004 at NFARS.

As the initial user of the MTMS document, *CTC* also was asked to provide feedback on the documentation provided in the MTMS. A few of the tests and material substrates defined in the MTMS need to be revisited for clarification to the end-user. The items to be reviewed include the following:

- The glass transition temperature test for polymer matrix composites may not be a true glass transition data point. This test may not be needed as part of the evaluation of alternative deicers.
- The oxidation resistance test for the carbon-carbon brake material may be too severe to indicate the true effects of the deicers to the substrate. The test parameters should be reviewed and revised to represent actual braking conditions. For baseline purposes, propylene-glycol based deicing fluids should be tested as well.
- Acceptance criteria should be listed for each test to allow for more quantitative evaluations of the data.
- It also would be helpful if guidelines were established for procuring standardized test specimens. Infrared window, carbon-carbon brake, and polymer matrix composite materials were expensive and difficult to acquire.
- The sealant specimen preparation needs to be better defined because the vendor specifications did not appear to meet the needs of this testing protocol as described in the text.
- Finally, the open-hole compression test for polymer matrix composites needs to be better documented, providing accurate diagrams for specimen and equipment setup. This test could not be included in this evaluation because a clear and accurate diagram of the specimen position in the test fixture could not be provided.

Appendix A
Metallic Materials Alternatives Immersion Data

Metallic Materials – Alternate Immersion Data

A286 Steel									
Deicer	Panel ID	Initial mass (g)	Mass after exposure to deicing solution (g)	Change in initial mass (g)	Final Inspection	Mass after corrosion stripping as per ASTM G1 (g)	Loss in mass after stripping (g)	Loss in mass after stripping (%)	Average Loss in mass after stripping (%)
Unexposed		59.0520		-59.0520	No Corrosion	Not Stripped	--	--	--
		60.7273		-60.7273	No Corrosion	Not Stripped	--	--	
		60.8332		-60.8332	No Corrosion	Not Stripped	--	--	
METSS ADF-2	03-1687-P	62.3185	62.3186	0.0001	No Corrosion	Not Stripped	--	--	--
	03-1688-P	63.5553	63.5555	0.0002	No Corrosion	Not Stripped	--	--	
	03-1689-P	60.1176	60.1180	0.0004	No Corrosion	Not Stripped	--	--	
Battelle D(3)	03-1690-P	61.1839	61.1845	0.0006	No Corrosion	Not Stripped	--	--	--
	03-1691-P	63.7904	63.7911	0.0007	No Corrosion	Not Stripped	--	--	
	03-1692-P	62.3367	62.3373	0.0006	No Corrosion	Not Stripped	--	--	
METSS RDF-2	03-1684-P	60.9299	60.9304	0.0005	No Corrosion	Not Stripped	--	--	--
	03-1685-P	71.9152	71.9158	0.0006	No Corrosion	Not Stripped	--	--	
	03-1686-P	66.7959	66.7963	0.0004	No Corrosion	Not Stripped	--	--	
Safeway KF Hot	03-1681-P	60.3298	60.3301	0.0003	No Corrosion	Not Stripped	--	--	--
	03-1682-P	69.7915	69.7918	0.0003	No Corrosion	Not Stripped	--	--	
	03-1683-P	71.8464	71.8468	0.0004	No Corrosion	Not Stripped	--	--	
AVIFORM L50	03-1678-P	61.7377	61.7383	0.0006	No Corrosion	Not Stripped	--	--	--
	03-1679-P	67.2129	67.2136	0.0007	No Corrosion	Not Stripped	--	--	
	03-1680-P	60.1219	60.1228	0.0009	No Corrosion	Not Stripped	--	--	

Metallic Materials – Alternate Immersion Data

4140 Steel									
Deicer	Panel ID	Initial mass (g)	Mass after exposure to deicing solution (g)	Change in initial mass (g)	Final Inspection	Mass after corrosion stripping as per ASTM G1 (g)	Loss in mass after stripping (g)	Loss in mass after stripping (%)	Average Loss in mass after stripping (%)
Unexposed		64.0695		-64.0695	No Corrosion	Not Stripped	--	--	--
		64.0974		-64.0974	No Corrosion	Not Stripped	--	--	
		64.1006		-64.1006	No Corrosion	Not Stripped	--	--	
METSS ADF-2	03-1717-P	64.2470	64.2483	0.0013	No Corrosion	Not Stripped	--	--	--
	03-1718-P	64.0258	64.0250	-0.0008	No Corrosion	Not Stripped	--	--	
	03-1719-P	63.9205	63.9202	-0.0003	No Corrosion	Not Stripped	--	--	
Battelle D(3)	03-1720-P	64.1592	64.1599	0.0007	Red Rust, light and spotty ~1%	64.1582	0.0010	0.0016	0.0027
	03-1721-P	63.8110	63.8108	-0.0002	Red Rust, light and spotty ~1%, 1/32 inch spot TDC edge	63.8089	0.0021	0.0033	
	03-1722-P	63.9929	63.9938	0.0009	Red Rust, light and spotty ~1%, 2 each 1/32 inch spots TDC edge	63.9909	0.0020	0.0031	
METSS RDF-2	03-1714-P	64.2565	64.2569	0.0004	No Corrosion	Not Stripped	--	--	--
	03-1715-P	63.8947	63.8952	0.0005	No Corrosion	Not Stripped	--	--	
	03-1716-P	64.0158	64.0168	0.0010	No Corrosion	Not Stripped	--	--	
Safeway KF Hot	03-1711-P	64.0711	64.0726	0.0015	Red Rust, light and spotty ~10-15% both sides	64.0674	0.0037	0.0058	0.0052
	03-1712-P	63.7526	63.7530	0.0004	Red Rust, light and spotty ~1% both sides	63.7486	0.0040	0.0063	
	03-1713-P	63.9025	63.9028	0.0003	Red Rust, light and spotty ~5% both sides	63.9003	0.0022	0.0034	
AVIFORM L50	03-1708-P	64.1699	64.1709	0.0010	Red Rust, light and spotty ~5%	64.1694	0.0005	0.0008	0.0017
	03-1709-P	63.8547	63.8559	0.0012	Red Rust, light and spotty ~1%	63.8542	0.0005	0.0008	
	03-1710-P	64.1810	64.1812	0.0002	Red Rust, light and spotty ~5%	64.1788	0.0022	0.0034	

Metallic Materials – Alternate Immersion Data

C630									
Deicer	Panel ID	Initial mass (g)	Mass after exposure to deicing solution (g)	Change in initial mass (g)	Final Inspection	Mass after corrosion stripping as per ASTM G1 (g)	Loss in mass after stripping (g)	Loss in mass after stripping (%)	Average Loss in mass after stripping (%)
Unexposed		60.2540		-60.2540	Not Tested	Not Stripped			
		59.9622		-59.9622	Not Tested	Not Stripped			
		63.9985		-63.9985	Not Tested	Not Stripped			
METSS ADF-2	03-1747-P	60.8728	60.8607	-0.0121	No Corrosion, Bluish colored area that appears to be made from contact with paper cloth.	60.8589	0.0139	0.0228	0.0225
	03-1748-P	59.2278	59.2162	-0.0116	No Corrosion, Bluish colored area that appears to be made from contact with paper cloth.	59.2149	0.0129	0.0218	
	03-1749-P	59.6438	59.6317	-0.0121	No Corrosion, Bluish colored area that appears to be made from contact with paper cloth.	59.6302	0.0136	0.0228	
Battelle D(3)	03-1750-P	58.9410	58.9415	0.0005	No Corrosion	Not Stripped	--	--	--
	03-1751-P	61.6296	61.6303	0.0007	No Corrosion	Not Stripped	--	--	
	03-1752-P	56.2823	56.2827	0.0004	No Corrosion	Not Stripped	--	--	
METSS RDF-2	03-1744-P	44.1619	44.1627	0.0008	No Corrosion, Mottled and discolored over entire area	44.1609	0.0010	0.0023	0.0019
	03-1745-P	56.9767	56.9777	0.0010	No Corrosion, Mottled and discolored over entire area	56.9759	0.0008	0.0014	
	03-1746-P	61.3549	61.3558	0.0009	No Corrosion, Mottled and discolored over entire area	61.3537	0.0012	0.0020	
Safeway KF Hot	03-1741-P	74.6599	74.6606	0.0007	No Corrosion, Some Discoloration	74.6590	0.0009	0.0012	0.0012
	03-1742-P	62.1920	62.1928	0.0008	No Corrosion, Discolored spots	62.1915	0.0005	0.0008	
	03-1743-P	56.7581	56.7587	0.0006	No Corrosion, Discolored spots	56.7572	0.0009	0.0016	
AVIFORM L50	03-1738-P	60.6323	60.6333	0.0010	No Corrosion	60.6325	0.0002	--	--
	03-1739-P	61.3077	61.3087	0.0010	No Corrosion	61.3076	0.0001	--	
	03-1740-P	67.6835	67.6843	0.0008	No Corrosion	67.6837	0.0002	--	

Metallic Materials – Alternate Immersion Data

AZ91E-T6 Cast Magnesium Alloy									
Deicer	Panel ID	Initial mass (g)	Mass after exposure to deicing solution (g)	Change in initial mass (g)	Final Inspection	Mass after corrosion stripping as per ASTM G1 (g)	Loss in mass after stripping (g)	Loss in mass after stripping (%)	Average Loss in mass after stripping (%)
Unexposed		14.7385		-14.7385	Not Tested	Not Stripped			
		14.3201		-14.3201	Not Tested	Not Stripped			
		15.6703		-15.6703	Not Tested	Not Stripped			
METSS ADF-2	03-1777-P	14.8736	14.8503	-0.0233	No Corrosion, dark staining	14.8373	0.0363	0.2441	0.2446
	03-1778-P	14.5408	14.5171	-0.0237	No Corrosion, dark staining	14.5036	0.0372	0.2558	
	03-1779-P	14.1129	14.0932	-0.0197	No Corrosion, dark staining	14.0799	0.0330	0.2338	
Battelle D(3)	03-1780-P	13.6010	13.6009	-0.0001	No Corrosion, dark staining	13.5922	0.0088	0.0647	0.0571
	03-1781-P	13.8988	13.9011	0.0023	No Corrosion, dark staining	13.8919	0.0069	0.0496	
	03-1782-P	13.5224	13.5260	0.0036	No Corrosion, dark staining	13.5147	0.0077	0.0569	
METSS RDF-2	03-1774-P	14.4652	14.3009	-0.1643	Pits ~35-50% of entire surface area, etching	13.9141	0.5511	3.8098	3.7872
	03-1775-P	15.5227	15.3599	-0.1628	Pits ~25-35% of entire surface area, etching	14.9823	0.5404	3.4814	
	03-1776-P	15.6816	15.5252	-0.1564	Pits ~35-50% of entire surface area, etching	15.0433	0.6383	4.0704	
Safeway KF Hot	03-1771-P	14.7188	14.9066	0.1878	Medium White Corrosion ~25-30%	14.4502	0.2686	1.8249	1.7919
	03-1772-P	14.7429	14.9487	0.2058	Medium White Corrosion ~25-30%	14.4702	0.2727	1.8497	
	03-1773-P	14.8265	15.0298	0.2033	Medium White Corrosion ~25-30%	14.5743	0.2522	1.7010	
AVIFORM L50	03-1768-P	15.2893	17.0172	1.7279	Heavy White Corrosion ~98%	14.4219	0.8674	5.6732	5.1586
	03-1769-P	13.5901	14.5272	0.9371	Heavy White Corrosion ~95%	12.8429	0.7472	5.4981	
	03-1770-P	14.4060	15.4000	0.9940	Heavy White Corrosion ~80%	13.7859	0.6201	4.3045	

Metallic Materials – Alternate Immersion Data

7075-T6 Bare Aluminum Alloy									
Deicer	Panel ID	Initial mass (g)	Mass after exposure to deicing solution (g)	Change in initial mass (g)	Final Inspection	Mass after corrosion stripping as per ASTM G1 (g)	Loss in mass after stripping (g)	Loss in mass after stripping (%)	Average Loss in mass after stripping (%)
Unexposed		22.1802		-22.1802	Not Tested	Not Stripped			
		22.1385		-22.1385	Not Tested	Not Stripped			
		22.1425		-22.1425	Not Tested	Not Stripped			
METSS ADF-2	03-1807-P	22.1162	22.1153	-0.0009	Filiform Corrosion in spots, ~10-15%	22.1122	0.0040	0.0181	0.0152
	03-1808-P	22.1711	22.1709	-0.0002	Filiform Corrosion in spots, ~10-15%	22.1684	0.0027	0.0122	
	03-1809-P	22.2115	22.2109	-0.0006	Filiform Corrosion in spots, ~5%	22.2081	0.0034	0.0153	
Battelle D(3)	03-1810-P	22.2703	22.2706	0.0003	No Corrosion	Not Stripped	--	--	--
	03-1811-P	22.1831	22.1834	0.0003	No Corrosion	Not Stripped	--	--	
	03-1812-P	22.2555	22.2558	0.0003	No Corrosion	Not Stripped	--	--	
METSS RDF-2	03-1804-P	22.2016	22.1919	-0.0097	Cloudy stained appearance over entire surface area.	22.1914	0.0102	0.0459	0.0699
	03-1805-P	22.0650	22.0530	-0.0120	Cloudy stained appearance over entire surface area.	22.0520	0.0130	0.0589	
	03-1806-P	22.1963	22.1739	-0.0224	Cloudy stained appearance over entire surface area.	22.1730	0.0233	0.1050	
Safeway KF Hot	03-1801-P	22.1366	22.1369	0.0003	No Corrosion	22.1368	-0.0002	-0.0009	-0.0002
	03-1802-P	22.1802	22.1806	0.0004	No Corrosion	22.1802	0.0000	0.0000	
	03-1803-P	22.1717	22.1720	0.0003	White spots, 8 ea.	22.1716	0.0001	0.0005	
AVIFORM L50	03-1798-P	22.2418	22.2424	0.0006	No Corrosion	Not Stripped	--	--	--
	03-1799-P	22.1525	22.1530	0.0005	No Corrosion	Not Stripped	--	--	
	03-1800-P	22.1812	22.1817	0.0005	No Corrosion	Not Stripped	--	--	

Test Parameter ID: Stress Corrosion Cracking	
Test Method: ASTM G-44, ASTM G-49, MTMS	
Project ID: 01020.003.100	
Lab Device ID: SCC Chamber	
Lab Analyst/Scientist: SB	**Date of Analysis: 9/29/03**

Sample ID	Test Results and Units
03-1693-P	No fracture
03-1694-P	No fracture
03-1695-P	No fracture
03-1696-P	No fracture
03-1697-P	No fracture
03-1698-P	No fracture
03-1699-P	No fracture
03-1700-P	No fracture
03-1701-P	No fracture
03-1702-P	No fracture
03-1703-P	No fracture
03-1704-P	No fracture
03-1705-P	No fracture
03-1706-P	No fracture
03-1707-P	No fracture
03-1723-P	No fracture
03-1724-P	No fracture
03-1725-P	No fracture
03-1726-P	No fracture
03-1727-P	No fracture
03-1728-P	No fracture
03-1729-P	No fracture
03-1730-P	No fracture
03-1731-P	No fracture
03-1732-P	No fracture

Notes:

Test Parameter ID: Stress Corrosion Cracking	
Test Method: ASTM G-44, ASTM G-49, MTMS	
Project ID: 01020.003.100	
Lab Device ID: SCC Chamber	
Lab Analyst/Scientist: SB	**Date of Analysis: 9/29/03**

Sample ID	Test Results and Units
03-1733-P	No fracture
03-1734-P	No fracture
03-1735-P	No fracture
03-1736-P	No fracture
03-1737-P	No fracture
03-1753-P	No fracture
03-1754-P	No fracture
03-1755-P	No fracture
03-1756-P	No fracture
03-1757-P	No fracture
03-1758-P	No fracture
03-1759-P	No fracture
03-1760-P	No fracture
03-1761-P	No fracture
03-1762-P	No fracture
03-1763-P	No fracture
03-1764-P	No fracture
03-1765-P	No fracture
03-1766-P	No fracture
03-1767-P	No fracture
03-1783-P	No fracture
03-1784-P	No fracture
03-1785-P	No fracture
03-1786-P	No fracture
03-1787-P	No fracture

Notes:

Test Parameter ID: Stress Corrosion Cracking	
Test Method: ASTM G-44, ASTM G-49, MTMS	
Project ID: 01020.003.100	
Lab Device ID: SCC Chamber	
Lab Analyst/Scientist: SB	**Date of Analysis: 9/29/03**

Sample ID	Test Results and Units
03-1788-P	Not tested (broke during loading)
03-1789-P	No fracture
03-1790-P	No fracture
03-1791-P	No fracture
03-1792-P	No fracture
03-1793-P	No fracture
03-1794-P	No fracture
03-1795-P	No fracture
03-1796-P	No fracture
03-1797-P	No fracture
03-1813-P	No fracture
03-1814-P	No fracture
03-1815-P	No fracture
03-1816-P	No fracture
03-1817-P	No fracture
03-1818-P	No fracture
03-1819-P	No fracture
03-1820-P	No fracture
03-1821-P	No fracture
03-1822-P	No fracture
03-1823-P	No fracture
03-1824-P	No fracture
03-1825-P	No fracture
03-1826-P	No fracture
03-1827-P	No fracture

Notes:

SCC Constant Strain Loading Data Sheet

Date Loaded	Operator	Lab ID No.	Deicing Solution	Material	Specimen ID	Rig ID	Theoretical Microstrain	Actual Microstrain
4/10/2003	TPB	03-1756-P	Safeway KF Hot	C630	C630-S-SKF-1	1	6992	6801
4/10/2003	TPB	03-1757-P	Safeway KF Hot	C630	C630-S-SKF-2	2	6992	6832
4/10/2003	TPB	03-1758-P	Safeway KF Hot	C630	C630-S-SKF-3	3	6992	6738
4/10/2003	TPB	03-1696-P	Safeway KF Hot	A286	A286-S-SKF-1	4	10034	9287
4/10/2003	TPB	03-1697-P	Safeway KF Hot	A286	A286-S-SKF-2	5	10034	9836
4/10/2003	TPB	03-1698-P	Safeway KF Hot	A286	A286-S-SKF-3	6	10034	9851
4/10/2003	TPB	03-1726-P	Safeway KF Hot	4140	4140-S-SKF-1	7	10415	10298
4/10/2003	TPB	03-1727-P	Safeway KF Hot	4140	4140-S-SKF-2	8	10415	10278
4/10/2003	TPB	03-1728-P	Safeway KF Hot	4140	4140-S-SKF-3	9	10415	10429
5/2/2003	TPB	03-1786-P	Safeway KF Hot	AZ91E	AZ91E-S-SKF-1	10	596	666
5/2/2003	TPB	03-1787-P	Safeway KF Hot	AZ91E	AZ91E-S-SKF-2	11	596	625
5/2/2003	TPB	03-1788-P	Safeway KF Hot	AZ91E	AZ91E-S-SKF-3	12	596	broke loading
5/2/2003	TPB	03-1816-P	Safeway KF Hot	7075	7075-S-SKF-1	13	6475	6290
5/2/2003	TPB	03-1817-P	Safeway KF Hot	7075	7075-S-SKF-2	14	6475	6338
5/2/2003	TPB	03-1818-P	Safeway KF Hot	7075	7075-S-SKF-3	15	6475	6169
5/21/2003	TPB	03-1765-P	Battelle D3	C630	C630-BD3-1	16	6992	6700
5/21/2003	TPB	03-1766-P	Battelle D3	C630	C630-BD3-2	17	6992	6740
5/21/2003	TPB	03-1767-P	Battelle D3	C630	C630-BD3-3	18	6992	6730
5/21/2003	TPB	03-1705-P	Battelle D3	A286	A286-BD3-1	19	10034	9699
5/21/2003	TPB	03-1706-P	Battelle D3	A286	A286-BD3-2	20	10034	9522
5/21/2003	TPB	03-1707-P	Battelle D3	A286	A286-BD3-3	21	10034	9710
5/21/2003	TPB	03-1735-P	Battelle D3	4140	4140-BD3-1	22	10415	9938
5/21/2003	TPB	03-1736-P	Battelle D3	4140	4140-BD3-2	23	10415	9765
5/21/2003	TPB	03-1737-P	Battelle D3	4140	4140-BD3-3	24	10415	10096
5/21/2003	TPB	03-1795-P	Battelle D3	AZ91E	AZ91E-BD3-1	25	596	591
5/21/2003	TPB	03-1796-P	Battelle D3	AZ91E	AZ91E-BD3-2	26	596	603
5/21/2003	TPB	03-1797-P	Battelle D3	AZ91E	AZ91E-BD3-3	27	596	565
5/21/2003	TPB	03-1825-P	Battelle D3	7075	7075-BD3-1	28	6475	6177
5/21/2003	TPB	03-1826-P	Battelle D3	7075	7075-BD3-2	29	6475	6286
5/21/2003	TPB	03-1827-P	Battelle D3	7075	7075-BD3-3	30	6475	6235

Metallic Materials – Stress Corrosion Cracking Strain Data

SCC Constant Strain Loading Data Sheet

Date Loaded	Operator	Lab ID No.	Deicing Solution	Material	Specimen ID	Rig ID	Theoretical Microstrain	Actual Microstrain
6/9/2003	TPB	03-1753-P	Aviform L50	C630	C630-AVI-1	31	6992	6550
6/9/2003	TPB	03-1754-P	Aviform L50	C630	C630-AVI-2	32	6992	6789
6/9/2003	TPB	03-1755-P	Aviform L50	C630	C630-AVI-3	33	6992	6668
6/9/2003	TPB	03-1693-P	Aviform L50	A286	A286-AVI-1	34	10034	9742
6/9/2003	TPB	03-1694-P	Aviform L50	A286	A286-AVI-2	35	10034	9688
6/9/2003	TPB	03-1695-P	Aviform L50	A286	A286-AVI-3	36	10034	9608
6/9/2003	TPB	03-1723-P	Aviform L50	4140	4140-AVI-1	37	10415	10057
6/9/2003	TPB	03-1724-P	Aviform L50	4140	4140-AVI-2	38	10415	10051
6/9/2003	TPB	03-1725-P	Aviform L50	4140	4140-AVI-3	39	10415	10176
6/9/2003	TPB	03-1783-P	Aviform L50	AZ91E	AZ91E-AVI-1	1	596	592
6/9/2003	TPB	03-1784-P	Aviform L50	AZ91E	AZ91E-AVI-2	2	596	601
6/9/2003	TPB	03-1785-P	Aviform L50	AZ91E	AZ91E-AVI-3	3	596	590
6/9/2003	TPB	03-1813-P	Aviform L50	7075	7075-AVI-1	4	6475	6225
6/9/2003	TPB	03-1814-P	Aviform L50	7075	7075-AVI-2	5	6475	6202
6/9/2003	TPB	03-1815-P	Aviform L50	7075	7075-AVI-3	6	6475	6253
7/3/2003	TPB	03-1762-P	METSS ADF-2	C630	C630-ADF-1	4	6992	6798
7/3/2003	TPB	03-1763-P	METSS ADF-2	C630	C630-ADF-2	5	6992	6850
7/3/2003	TPB	03-1764-P	METSS ADF-2	C630	C630-ADF-3	6	6992	6601
7/3/2003	TPB	03-1702-P	METSS ADF-2	A286	A286-ADF-1	7	10034	9796
7/3/2003	TPB	03-1703-P	METSS ADF-2	A286	A286-ADF-2	8	10034	9825
7/3/2003	TPB	03-1704-P	METSS ADF-2	A286	A286-ADF-3	9	10034	9924
7/3/2003	TPB	03-1732-P	METSS ADF-2	4140	4140-ADF-1	13	10415	10291
7/3/2003	TPB	03-1733-P	METSS ADF-2	4140	4140-ADF-2	14	10415	10330
7/3/2003	TPB	03-1734-P	METSS ADF-2	4140	4140-ADF-3	15	10415	10322
7/3/2003	TPB	03-1792-P	METSS ADF-2	AZ91E	AZ91E-ADF-1	18	596	576
7/3/2003	TPB	03-1793-P	METSS ADF-2	AZ91E	AZ91E-ADF-2	19	596	588
7/3/2003	TPB	03-1794-P	METSS ADF-2	AZ91E	AZ91E-ADF-3	20	596	588
7/3/2003	TPB	03-1822-P	METSS ADF-2	7075	7075-ADF-1	21	6475	6195
7/3/2003	TPB	03-1823-P	METSS ADF-2	7075	7075-ADF-2	22	6475	6077
7/3/2003	TPB	03-1824-P	METSS ADF-2	7075	7075-ADF-3	23	6475	6126

Metallic Materials – Stress Corrosion Cracking Strain Data

SCC Constant Strain Loading Data Sheet

Date Loaded	Operator	Lab ID No.	Deicing Solution	Material	Specimen ID	Rig ID	Theoretical Microstrain	Actual Microstrain
9/12/2003	TPB	03-1759-P	METSS RDF-2	C630	C630-RDF-1	26	6992	6683
9/12/2003	TPB	03-1760-P	METSS RDF-2	C630	C630-RDF-2	27	6992	6518
9/12/2003	TPB	03-1761-P	METSS RDF-2	C630	C630-RDF-3	28	6992	6539
9/12/2003	TPB	03-1699-P	METSS RDF-2	A286	A286-RDF-1	29	10034	9547
9/12/2003	TPB	03-1700-P	METSS RDF-2	A286	A286-RDF-2	30	10034	9572
9/12/2003	TPB	03-1701-P	METSS RDF-2	A286	A286-RDF-3	31	10034	9547
9/12/2003	TPB	03-1729-P	METSS RDF-2	4140	4140-RDF-1	32	10415	10097
9/12/2003	TPB	03-1730-P	METSS RDF-2	4140	4140-RDF-2	33	10415	10210
9/12/2003	TPB	03-1731-P	METSS RDF-2	4140	4140-RDF-3	34	10415	10205
9/12/2003	TPB	03-1789-P	METSS RDF-2	AZ91E	AZ91E-RDF-1	35	596	574
9/12/2003	TPB	03-1790-P	METSS RDF-2	AZ91E	AZ91E-RDF-2	36	596	596
9/12/2003	TPB	03-1791-P	METSS RDF-2	AZ91E	AZ91E-RDF-3	37	596	562
9/12/2003	TPB	03-1819-P	METSS RDF-2	7075	7075-RDF-1	38	6475	6218
9/12/2003	TPB	03-1820-P	METSS RDF-2	7075	7075-RDF-2	39	6475	5985
9/12/2003	TPB	03-1821-P	METSS RDF-2	7075	7075-RDF-3	40	6475	6235

constant strain

Material	Measured Yield (ksi)	Average Yield (ksi)	80% of Average (ksi)	Equivalent Microstrain (in/in)x10^{-6}
C630	95.2	92.7	74.1	6992
	90.1			
A286	133.1	133.0	106.4	10034
	132.8			
4140	138.3	138.0	110.4	10415
	137.7			
AZ91E	7.9	7.9	6.3	596
	7.9			
7075	83.9	85.8	68.6	6475
	87.7			

Polymer Matrix Composites – Fiber Content Data

Appendix B
Polymer Matrix Composites Density Data

Material Quality Control Tests

The following tag end tests, density/specific gravity and fiber content, as well as thermal analysis (listed in the body of the report, since testing after exposure was also conducted) were performed on the polymer matrix composite sheet materials to verify the quality of these materials prior to exposure to the deicers.

Density/Specific Gravity

Test Description

The density test is a tag end test of the original polymer matrix composite material. Four 1 x 1-inch specimens were cut from each polymer matrix composite sheet. The temperature of the water in the immersion tank was measured and recorded. The specimen and sinker were weighed in air to the nearest 0.1 milligram. The sinker was used to weight all specimens because they were lighter than water. Ensuring that the sample holder does not contact the side of the tank, the specimen (and sinker) were placed in the sample holder and completely immersed in the tank. By rubbing with a wire, any bubbles attached to the sample holder, specimen, and sinker were removed, and the mass of the sample holder, sample, and sinker was recorded. The sample holder and sinker then were immersed in water at the same depth as the sample, and this weight was recorded. The density was determined using the calculation listed in ASTM D 792. The density of each sheet was calculated based on the average density for the four specimens per sheet.

Test Methodology

Parameters	1 x 1-inch samples measured on a balance equipped with a suspended sample holder and immersion tank
Type/Number of specimens	PMC 1 and PMC 2 / 4
Trials per specimen	1
Acceptance Criteria	Repeat density readings within ±1%.
Reference Document	ASTM D 792-00, MTMS Section 5.4.1

Deviations or Interpretation of Test Method

There were no deviations to the specified test description.

Test Results

The average density of four polymer matrix composite specimens for each original material is listed in Table 7. The raw laboratory data is in Appendix B.

Table 1. Polymer Matrix Density Results

Polymer Matrix Composite Material	Density Range (g/cm^3)
977-3 Epoxy Resin	1.55-1.57
5250-4 BMI Resin	1.56-1.57

Discussion of the Results

The polymer matrix composite supplier did not provide a standard density for the materials. Based on the results found in Report No. MLS-98-126, *Exposure of Polymer Matrix Composites to Environmentally Friendly Runway Deicers (Mechanical and Physical Property Evaluation),* dated 27 July 1998, the 5250-4 composite had a density of 1.59 g/cc, which is comparable to the data collected during this testing. This data was not included in the final pass/fail summary comparison.

Fiber Content

Test Description

Another tag end test includes determining the fiber content of the original polymer matrix composite materials as percent by weight for the density specimens cut from PMC 1 and PMC 2 polymer matrix composite sheets. Each specimen was weighed to the nearest 0.1 milligram, and placed in a separate beaker containing at least 30 milliliters of 70% nitric acid. Constant heat was applied with a hot plate up to temperatures of 40°C. Once the reinforcement/laminate combination dissolved, the contents of the beaker were vacuum filtered into a pre-weighed filter-lined crucible. The filter was washed with distilled water, then acetone, and baked in an oven at 100°C for approximately one hour. The filter then was cooled in a desiccator and weighed in the holder to the nearest 0.1-milligram. The fiber content was calculated, in weight percent, by dividing the final mass by the initial mass of the specimen, then multiplying by 100.

Test Methodology

Parameters	1 x 1-inch samples digested in nitric acid to remove the laminate material
Type/Number of specimens	PMC 1 and PMC 2 / 4 specimens per sheet
Trials per specimen	1
Acceptance Criteria	Compare to the standard value supplied by the composite vendor, where available.
Reference Document	ASTM D 3171-99, MTMS Section 5.4.1

Deviations or Interpretation of Test Method

There were no deviations from the stated test description.

Test Results

The average percent fiber content of four polymer matrix composite specimens for each original material is listed in Table 8. The raw laboratory data is in Appendix B.

Table 2. Polymer Matrix Fiber Content Results

Polymer Matrix Composite Material	Average Fiber Content, weight%	Fiber Content Range, weight %	% Difference from Vendor Standard
977-3 Epoxy Resin	76.4	75.5-77.6	N/A
5250-4 BMI Resin	71.7	71.0-72.8	N/A

Discussion of the Results

The fiber content was analyzed to provide baseline information on the original material and compare to standard values. However, the polymer matrix composite supplier did not provide standard fiber content data for the materials; therefore, a comparison could not be made. This is for informational purposes only.

Raw Data Tables

977-3 Epoxy Resin

Sample ID	Dry Mass (g)	Wet Mass (g)	Density (g/cm3)	Standard Deviation	Average Density (g/cm3)
03-2350-P	1.652	0.601	1.567	0.007	1.56
03-2351-P	1.587	0.568	1.553		
03-2352-P	1.742	0.625	1.555		
03-2353-P	1.647	0.597	1.564		

5250-4 BM Resin

Sample ID	Dry Mass (g)	Wet Mass (g)	Density (g/cm3)	Standard Deviation	Average Density (g/cm3)
03-2222-P	1.028	0.373	1.565	0.002	1.56
03-2223-P	1.027	0.373	1.566		
03-2224-P	1.030	0.374	1.565		
03-2225-P	1.023	0.370	1.562		

Polymer Matrix Composites – Fiber Content Data

977-3 Epoxy Resin

Panel ID	Initial Weight	Filter and Watch Glass	Filter, Watch Glass and Sample	Final Weight	Fiber Content (%)	Standard Deviation	Average Fiber Content (%)
03-2226	1.0653	55.791	56.5953	0.8043	75.5	0.88	**76.4**
03-2227	1.0913	55.1951	56.0419	0.8468	77.6		
03-2228	1.0704	41.9411	42.756	0.8149	76.1		
03-2229	1.0999	55.4511	56.2915	0.8404	76.4		

5250-4 BM Resin

Panel ID	Initial Weight	Filter and Watch Glass	Filter, Watch Glass and Sample	Final Weight	Fiber Content (%)	Standard Deviation	Average Fiber Content (%)
03-2354	1.7222	12.3955	13.6499	1.2544	72.8	0.85	**71.7**
03-2355	1.7244	13.9217	15.1459	1.2242	71.0		
03-2356	1.7316	12.2147	13.4612	1.2465	72.0		
03-2357	1.702	13.2934	14.5043	1.2109	71.1		

Polymer Matrix Composites – In-Plane Shear Data

977-3 Epoxy Resin

Deicer	Lab ID	Test Day	Dry Weight (gm)	Post Exposure Weight (gm)	Width (in)	Thicknes s (in)	Area (in^2)	Offset Location (%)	Maximum Shear Load (lbf)	Maximum Shear Stress (psi)	Offset Shea Load (lbf)	Offset Shear Stress (psi)	Standard Deviation	**Average Offset Shear Stress (psi)**
	03-2330-P	Monday	10.6472	10.6523	0.9719	0.0459	0.0446	5.00	---	---	1105	12385		
Unexposed	03-2331-P	Tuesday	10.7250	10.7300	0.9766	0.0468	0.0457	5.00	---	---	1110	12143	294	**12419**
	03-2332-P	Wednesday	10.5557	10.5601	0.9649	0.0447	0.0431	5.00	---	---	1098	12729		
METSS ADF-2	03-2290-P	Monday	10.6780	10.6892	0.9790	0.0455	0.0445	5.00	---	---	1120	12572		
	03-2291-P	Tuesday	10.6172	10.6279	0.9775	0.0453	0.0443	5.00	---	---	1095	12364	110	**12489**
	03-2292-P	Wednesday	10.8196	10.8300	0.9994	0.0450	0.0450	5.00	---	---	1127	12530		
	03-2310-P	Monday	10.8155	10.8269	0.9887	0.0458	0.0453	5.00	---	---	1155	12753		
Battelle D(3)	03-2311-P	Tuesday	10.7509	10.7602	1.0052	0.0462	0.0464	5.00	---	---	1127	12134	316	**12406**
	03-2312-P	Wednesday	10.7073	10.7197	0.9976	0.0454	0.0453	5.00	---	---	1117	12331		
METSS RDF-2	03-2270-P	Monday	10.7334	10.7423	0.9981	0.0457	0.0456	5.00	---	---	1125	12332		
	03-2271-P	Tuesday	10.7785	10.7935	0.9930	0.0453	0.0450	5.00	---	---	1117	12416	123	**12441**
	03-2272-P	Wednesday	10.6421	10.6528	0.9827	0.0452	0.0444	5.00	---	---	1117	12574		
Safeway KF Hot	03-2250-P	Monday	10.8969	10.9045	1.0055	0.0460	0.0463	5.00	---	---	1125	12161		
	03-2251-P	Tuesday	10.7085	10.7186	0.9915	0.0440	0.0436	5.00	---	---	1095	12550	270	**12464**
	03-2252-P	Wednesday	10.8071	10.8170	0.9858	0.0458	0.0451	5.00	---	---	1145	12680		
	03-2230-P	Monday	10.8797	10.9235	0.9924	0.0459	0.0456	5.00	---	---	1125	12349		
Aviform L50	03-2231-P	Tuesday	10.7988	10.8065	1.0031	0.0461	0.0462	5.00	---	---	1127	12186	242	**12399**
	03-2232-P	Wednesday	10.9165	10.8864	0.9999	0.0451	0.0451	5.00	---	---	1142	12662		

5250-4 BM Resin

Deicer	Lab ID	Test Day	Dry Weight (gm)	Post Exposure Weight (gm)	Width (in)	Thickness (in)	Area (in^2)	Offset Location (%)	Maximum Shear Load (lbf)	Maximum Shear Stress (psi)	Offset Shea Load (lbf)	Offset Shear Stress (psi)	Standard Deviation	Average Offset Shear Stress (psi)
Unexposed	03-2458-P	Monday	17.5143	17.5219	0.9962	0.0745	0.0742	5.00	1590	236.0	1525	10274	200	**10438**
	03-2459-P	Tuesday	17.4380	17.4459	0.9890	0.0736	0.0728	5.00	1602	233.2	1552	10661		
	03-2460-P	Wednesday	17.2566	17.2632	0.9892	0.0733	0.0725	4.21	1582	229.4	1505	10378		
METSS ADF-2	03-2418-P	Monday	17.3555	17.3816	0.9932	0.0739	0.0734	5.00	1595	234.1	1568	10682	68	**10673**
	03-2419-P	Tuesday	17.4853	17.5151	1.0004	0.0744	0.0744	5.00	1585	235.9	1578	10601		
	03-2420-P	Wednesday	17.5090	17.5333	0.9921	0.0737	0.0731	5.00	1617	236.5	1570	10736		
Battelle D(3)	03-2438-P	Monday	17.4416	17.4684	0.9968	0.0730	0.0728	5.00	1605	233.6	1545	10616	44	**10591**
	03-2439-P	Tuesday	17.4486	17.4775	0.9980	0.0732	0.0731	5.00	1602	234.1	1540	10540		
	03-2440-P	Wednesday	17.4698	17.4885	0.9965	0.0742	0.0739	5.00	1610	238.1	1570	10617		
METSS RDF-2	03-2398-P	Monday	17.4987	17.5280	0.9971	0.0742	0.0740	5.00	1612	238.5	1575	10644	154	**10652**
	03-2399-P	Tuesday	17.5452	17.5674	0.9961	0.0736	0.0733	5.00	1602	234.9	1585	10810		
	03-2400-P	Wednesday	17.4151	17.4355	0.9939	0.0729	0.0725	3.84	1602	232.1	1522	10503		
Safeway KF Hot	03-2378-P	Monday	17.5490	17.5100	0.9972	0.0734	0.0732	4.22	1610	235.7	1570	10725	649	**10368**
	03-2379-P	Tuesday	17.4994	17.5257	0.9963	0.0736	0.0733	5.00	1595	233.9	1578	10760		
	03-2380-P	Wednesday	17.5035	17.5362	0.9990	0.0805	0.0804	5.00	1595	256.5	1547	9618		
Aviform L50	03-2358-P	Monday	17.5152	17.5323	0.9972	0.0742	0.0740	5.00	1620	239.7	1542	10420	110	**10513**
	03-2359-P	Tuesday	17.5711	17.5972	0.9970	0.0746	0.0744	3.74	1582	235.3	1582	10635		
	03-2360-P	Wednesday	17.5834	17.6152	1.0015	0.0739	0.0740	5.00	1615	239.1	1552	10485		

977-3 Epoxy Resin

Deicer	Sample ID	Enthalpy of Transition (J/g)	Tg value* (°C)	Average Tg value* (°C)
Unexposed	03-2235-P	5.7	270.7	**270.2**
	03-2236-P	3.7	269.7	
METSS ADF-2	03-2336-P	3.0	270.0	**269.7**
	03-2335-P	4.7	269.4	
Battelle D(3)	03-2315-P	1.2	270.7	**270.2**
	03-2316-P	2.1	269.7	
METSS RDF-2	03-2295-P	3.0	269.7	**269.9**
	03-2296-P	2.6	270.0	
Safeway KF Hot	03-2275-P	1.8	272.0	**270.9**
	03-2276-P	2.3	269.7	
Aviform L50	03-2255-P	2.5	269.3	**269.7**
	03-2256-P	3.1	270.0	

5250-4 BM Resin

Deicer	Sample ID	Enthalpy of Transition (J/g)	Tg value* (°C)	Average Tg value* (°C)
Unexposed	03-2463-P	16.6	266.0	**266.0**
	03-2464-P	15.6	266.0	
METSS ADF-2	03-2443-P	14.4	259.0	**259.0**
	03-2444-P	14.3	259.0	
Aviform L50	03-2363-P	13.7	262.0	**262.5**
	03-2364-P	15.1	263.0	
METSS RDF-2	03-2403-P	15.0	262.0	**261.7**
	03-2404-P	15.0	261.3	
Safeway KF Hot	03-2383-P	13.8	262.3	**262.7**
	03-2384-P	14.3	263.0	
Battelle D(3)	03-2423-P	14.4	261.7	**261.9**
	03-2424-P	14.6	262.0	

Glass Transition Temperatures (Tg) measured by DSC for Polymer Matrix materials

Tg value* - Upon measuring the Tg values for these materials, it became evident that these peak values may not be due to glass transitions within the materials. Mechanical stresses may have been introduced into the materials during manufacturing and the peaks could be those stresses being released from the materials during heating. To further investigate this theory, two of the tag end samples, 03-2463-P and 03-2235-P, were heated a second time. The second heating curves showed no peaks or changes in the baseline at the temperatures given on the left. Hence, the transition that is indicated by the temperature / enthalpy values is not reversible. Glass transitions within materials, by definition, are reversible. Therefore, this transition being investigated may not be a true glass transition.

977-3 Epoxy Resin

Deicer	Panel ID	Aluminum	Graphite
Deionized Water	03-2337	0	0
	03-2338	1	0
	03-2339	0	0
	Average:	**0-1**	**0**
METSS ADF-2	03-2297	3	0
	03-2298	2	0
	03-2299	3	0
	Average:	**2-3**	**0**
Battelle D(3)	03-2317	1	0
	03-2318	1	0
	03-2319	1	0
	Average:	**1**	**0**
METSS RDF-2	03-2277	4	2
	03-2278	4	3
	03-2279	4	0
	Average:	**4**	**0-3**
Clariant Safeway KF Hot	03-2257	2	0
	03-2258	2	0
	03-2259	2	0
	Average:	**2**	**0**
Hydro Chemicals AVIFORM L50	03-2237	1	0
	03-2238	0	1
	03-2239	0	0
	Average:	**0-1**	**0-1**

Aluminum Rating System
0- No Visible Corrosion
1- Very Slight Corrosion (Up to 5% of the surface area corroded)
2- Slight Corrosion (5-10%)
3- Moderate Corrosion (10-25%)
4- Extensive Corrosion or Pitting (25% or more)

Graphite Rating System
0- No Visible Pitting
1- Very Slight Pitting (up to 5% of the surface area pitted)
2- Slight Pitting (5-10%)
3- Moderate Pitting (10-25%)
4- Extensive Pitting (25% or more)

5250-4 BM Resin

Deicer	Panel ID	Aluminum	Graphite
Deionized Water	03-2465	0	0
	03-2466	0	0
	03-2467	4	1
	Average:	**0-4**	**0-1**
METSS ADF-2	03-2425	3	0
	03-2426	3	1
	03-2427	1	0
	Average:	**1-3**	**0-1**
Battelle D(3)	03-2445	1	1
	03-2446	0	0
	03-2447	1	0
	Average:	**0-1**	**0-1**
METSS RDF-2	03-2405	4	4
	03-2406	3	3
	03-2407	4	3
	Average:	**3-4**	**3-4**
Clariant Safeway KF Hot	03-2385	2	0
	03-2386	2	0
	03-2387	2	0
	Average:	**2**	**0**
Hydro Chemicals AVIFORM L50	03-2365	1	0
	03-2366	2	0
	03-2367	0	0
	Average:	**0-2**	**0**

977-3 Epoxy Resin

Deicer	Lab ID	Dry Weight (gm)	Post Exposure Weight (gm)	Initial Barcol Indentation Hardness	Final Barcol Indentation Hardness	Average Final Barcol Indentation Hardness
Unexposed	03-2333-P	2.1657	2.1657	82.2	82.2	
	03-2334-P	2.2080	2.2088	80.4	81.8	82.0
METSS ADF-2	03-2293-P	2.1899	2.1924	82.8	81.6	
	03-2294-P	2.2192	2.2216	82.2	82.0	81.8
Battelle D(3)	03-2313-P	2.1450	2.1459	82.6	81.0	
	03-2314-P	2.2229	2.2242	82.0	79.8	80.4
METSS RDF-2	03-2273-P	2.1360	2.1366	82.6	81.6	
	03-2274-P	2.1525	2.1530	83.6	82.0	81.8
Safeway KF Hot	03-2253-P	2.2152	2.2160	82.8	81.2	
	03-2254-P	2.1512	2.1511	82.2	82.2	81.7
Aviform L50	03-2233-P	2.1894	2.1896	83.6	81.2	
	03-2234-P	2.2039	2.2046	83.4	81.4	81.3

5250-4 BM Resin

Deicer	Lab ID	Dry Weight (gm)	Post Exposure Weight (gm)	Initial Barcol Indentation Hardness	Final Barcol Indentation Hardness	Average Final Barcol Indentation Hardness
Unexposed	03-2461-P	3.4950	3.4950	82.8	82.6	
	03-2462-P	3.5190	3.5190	82.6	82.8	82.7
METSS ADF-2	03-2421-P	3.4178	3.4243	82.8	80.8	
	03-2422-P	3.4966	3.4996	83.2	82.8	81.8
Battelle D(3)	03-2441-P	3.4672	3.4754	83.2	82.6	
	03-2442-P	3.4873	3.4883	82.6	81.8	82.2
METSS RDF-2	03-2401-P	3.4298	3.4326	82.8	80.2	
	03-2402-P	3.5245	3.5275	83.4	83.2	81.7
Safeway KF Hot	03-2381-P	3.2979	3.2984	83.0	83.0	
	03-2382-P	3.3660	3.3664	82.8	82.6	82.8
Aviform L50	03-2361-P	3.4765	3.4768	83.0	82.4	
	03-2362-P	3.4785	3.4791	83.6	82.6	82.5

977-3 Epoxy Resin

Deicer	Panel ID	Dry Weights Mass 1	Dry Weights Mass 2	Dry Weights Average	Final Weights Mass 1	Final Weights Mass 2	Final Weights Average	Weight Loss Due to Thermal Exposure (g)	Weight Loss Due to Thermal Exposure (mg)	**Average Weight Loss Due to Thermal Exposure (mg)**	Total Surface Area (cm^2)	Weight Loss Per Surface Area (mg/cm^2)	**Average Weight Loss Per Surface Area (mg/cm^2)**
Deionized Water	O3-2340	1.0290	1.0293	1.0292	1.0248	1.0246	1.0247	0.0045	4.45	**4.705**	13.8472	0.3214	**0.341**
	O3-2341	1.0304	1.0302	1.0303	1.0260	1.0267	1.0264	0.0040	3.95		13.5552	0.2914	
	O3-2342	1.0426	1.0429	1.0428	1.0386	1.0386	1.0386	0.0041	4.15		14.0808	0.2947	
	O3-2343	1.0306	1.0315	1.0311	1.0270	1.0264	1.0267	0.0044	4.35		13.7222	0.3170	
	O3-2344	1.0279	1.0282	1.0281	1.0234	1.0234	1.0234	0.0046	4.65		13.5809	0.3424	
	O3-2345	1.0592	1.0591	1.0592	1.0546	1.0553	1.0550	0.0042	4.20		13.9018	0.3021	
	O3-2346	1.0708	1.0714	1.0711	1.0669	1.0661	1.0665	0.0046	4.60		13.9270	0.3303	
	O3-2347	1.0520	1.0535	1.0528	1.0478	1.0477	1.0478	0.0050	5.00		13.7663	0.3632	
	O3-2348	1.0349	1.0349	1.0349	1.0292	1.0292	1.0292	0.0057	5.70		13.6430	0.4178	
	O3-2349	1.0502	1.0501	1.0502	1.0441	1.0442	1.0442	0.0060	6.00		13.8443	0.4334	
METSS ADF-2	O3-2300	1.0563	1.0567	1.0565	1.0515	1.0512	1.0514	0.0051	5.15	**4.91**	31.1651	0.1652	**0.2888**
	O3-2301	1.0585	1.0587	1.0586	1.0532	1.0527	1.0530	0.0056	5.65		22.4356	0.2518	
	O3-2302	1.0215	1.0216	1.0216	1.0166	1.0162	1.0164	0.0051	5.15		22.6181	0.2277	
	O3-2303	1.0379	1.0382	1.0381	1.0331	1.0332	1.0332	0.0049	4.90		23.0994	0.2121	
	O3-2304	1.0570	1.0568	1.0569	1.0520	1.0520	1.0520	0.0049	4.90		14.2893	0.3429	
	O3-2305	1.0535	1.0532	1.0534	1.0488	1.0487	1.0488	0.0046	4.60		13.7991	0.3334	
	O3-2306	1.0954	1.0955	1.0955	1.0905	1.0908	1.0907	0.0048	4.80		14.0833	0.3408	
	O3-2307	1.0242	1.0246	1.0244	1.0198	1.0198	1.0198	0.0046	4.60		13.7526	0.3345	
	O3-2308	1.0525	1.0529	1.0527	1.0480	1.0481	1.0481	0.0047	4.65		13.6800	0.3399	
	O3-2309	1.0479	1.0476	1.0478	1.0430	1.0431	1.0431	0.0047	4.70		13.8514	0.3393	
Battelle D^3	O3-2320	1.0651	1.0654	1.0653	1.0599	1.0598	1.0599	0.0054	5.40	**5.30**	13.9457	0.3872	**0.3832**
	O3-2321	1.0451	1.0455	1.0453	1.0406	1.0405	1.0406	0.0048	4.75		13.7974	0.3443	
	O3-2322	1.0548	1.0548	1.0548	1.0498	1.0494	1.0496	0.0052	5.20		13.8792	0.3747	
	O3-2323	1.0545	1.0541	1.0543	1.0486	1.0488	1.0487	0.0056	5.60		13.8432	0.4045	
	O3-2324	1.0493	1.0494	1.0494	1.0442	1.0441	1.0442	0.0052	5.20		13.7671	0.3777	
	O3-2325	1.0552	1.0543	1.0548	1.0497	1.0499	1.0498	0.0049	4.95		13.8204	0.3582	
	O3-2326	1.0590	1.0589	1.0590	1.0540	1.0539	1.0540	0.0050	5.00		13.8700	0.3605	
	O3-2327	1.0602	1.0595	1.0599	1.0539	1.0536	1.0538	0.0061	6.10		13.8425	0.4407	
	O3-2328	1.0536	1.0536	1.0536	1.0480	1.0480	1.0480	0.0056	5.60		13.9155	0.4024	
	O3-2329	1.0409	1.0409	1.0409	1.0356	1.0357	1.0357	0.0052	5.25		13.7312	0.3823	

977-3 Epoxy Resin

		Dry Weights			Final Weights			Weight Loss Due to Thermal	Weight Loss Due to Thermal	**Average Weight Loss Due to Thermal**	Total Surface	Weight Loss Per Surface Area	**Average Weight Loss Per Surface Area**
Deicer	Panel ID	Mass 1	Mass 2	Average	Mass 1	Mass 2	Average	Exposure (g)	Exposure (mg)	**Exposure (mg)**	Area (cm^2)	(mg/cm^2)	**(mg/cm^2)**
METSS RDF-2	O3-2280	1.0275	1.0276	1.0276	1.0232	1.0230	1.0231	0.0045	4.45	**4.32**	13.6497	0.3260	**0.3124**
	O3-2281	1.0485	1.0485	1.0485	1.0442	1.0438	1.0440	0.0045	4.50		13.9191	0.3233	
	O3-2282	1.0412	1.0415	1.0414	1.0368	1.0369	1.0369	0.0045	4.50		13.8315	0.3253	
	O3-2283	1.0590	1.0586	1.0588	1.0544	1.0541	1.0543	0.0045	4.55		13.9797	0.3255	
	O3-2284	1.0070	1.0076	1.0073	1.0033	1.0036	1.0035	0.0038	3.85		13.4385	0.2865	
	O3-2285	1.0308	1.0312	1.0310	1.0267	1.0268	1.0268	0.0043	4.25		13.6528	0.3113	
	O3-2286	1.0688	1.0688	1.0688	1.0643	1.0644	1.0644	0.0044	4.45		14.1634	0.3142	
	O3-2287	1.0636	1.0640	1.0638	1.0596	1.0598	1.0597	0.0041	4.10		13.9092	0.2948	
	O3-2288	1.0810	1.0815	1.0813	1.0771	1.0770	1.0771	0.0042	4.20		13.9952	0.3001	
	O3-2289	1.0560	1.0567	1.0564	1.0520	1.0520	1.0520	0.0044	4.35		13.7287	0.3169	
Clariant Safeway KF Hot	O3-2260	1.0620	1.0619	1.0620	1.0569	1.0567	1.0568	0.0051	5.15	**5.19**	13.8221	0.3726	**0.3745**
	O3-2261	1.0709	1.0711	1.0710	1.0653	1.0651	1.0652	0.0058	5.80		14.0588	0.4126	
	O3-2262	1.0506	1.0505	1.0506	1.0454	1.0456	1.0455	0.0050	5.05		13.6969	0.3687	
	O3-2263	1.0561	1.0561	1.0561	1.0508	1.0508	1.0508	0.0053	5.30		13.7806	0.3846	
	O3-2264	1.0345	1.0345	1.0345	1.0289	1.0290	1.0290	0.0055	5.55		13.5865	0.4085	
	O3-2265	1.0665	1.0663	1.0664	1.0612	1.0612	1.0612	0.0052	5.20		13.9609	0.3725	
	O3-2266	1.0216	1.0216	1.0216	1.0172	1.0169	1.0171	0.0046	4.55		13.5161	0.3366	
	O3-2267	1.0774	1.0779	1.0777	1.0729	1.0725	1.0727	0.0050	4.95		14.1496	0.3498	
	O3-2268	1.0465	1.0465	1.0465	1.0413	1.0412	1.0413	0.0053	5.25		13.7611	0.3815	
	O3-2269	1.0865	1.0865	1.0865	1.0816	1.0813	1.0815	0.0051	5.05		14.1393	0.3572	
Hydro Chemicals AVIFORM L50	O3-2240	1.0398	1.0399	1.0399	1.0343	1.0343	1.0343	0.0055	5.55	**4.88**	14.0196	0.3959	**0.3522**
	O3-2241	1.0317	1.0317	1.0317	1.0268	1.0269	1.0269	0.0049	4.85		13.4948	0.3594	
	O3-2242	1.0790	1.0790	1.0790	1.0739	1.0740	1.0740	0.0051	5.05		14.1859	0.3560	
	O3-2243	1.0718	1.0718	1.0718	1.0664	1.0665	1.0665	0.0053	5.35		14.0079	0.3819	
	O3-2244	1.0504	1.0504	1.0504	1.0457	1.0456	1.0457	0.0047	4.75		13.9657	0.3401	
	O3-2245	0.9965	0.9961	0.9963	0.9919	0.9921	0.9920	0.0043	4.30		13.3797	0.3214	
	O3-2246	1.0479	1.0475	1.0477	1.0428	1.0428	1.0428	0.0049	4.90		13.6129	0.3600	
	O3-2247	1.0365	1.0367	1.0366	1.0321	1.0324	1.0323	0.0044	4.35		13.5440	0.3212	
	O3-2248	1.1002	1.1002	1.1002	1.0952	1.0953	1.0953	0.0050	4.95		14.1851	0.3490	
	O3-2249	1.0716	1.0713	1.0715	1.0668	1.0667	1.0668	0.0047	4.70		13.9412	0.3371	

5250-4 BM Resin

Deicer	Panel ID	Dry Weights Mass 1	Dry Weights Mass 2	Dry Weights Average	Final Weights Mass 1	Final Weights Mass 2	Final Weights Average	Weight Loss Due to Thermal Exposure (g)	Weight Loss Due to Thermal Exposure (mg)	**Average Weight Loss Due to Thermal Exposure (mg)**	Total Surface Area (cm^2)	Weight Loss Per Surface Area (mg/cm^2)	**Average Weight Loss Per Surface Area (mg/cm^2)**
	O3-2408	1.6857	1.6858	1.6858	1.6901	1.6898	1.6900	-0.0042	-4.20		14.4423	-0.2908	
	O3-2409	1.6928	1.6930	1.6929	1.6970	1.6969	1.6970	-0.0041	-4.05		14.6612	-0.2762	
	O3-2410	1.6705	1.6707	1.6706	1.6743	1.6743	1.6743	-0.0037	-3.70		14.3984	-0.2570	
	O3-2411	1.6357	1.6357	1.6357	1.6979	1.6977	1.6978	-0.0621	-62.10		14.1893	-4.3765	
METSS RDF-2	O3-2412	1.7050	1.7051	1.7051	1.7086	1.7086	1.7086	-0.0035	-3.55	**-2.49**	14.7401	-0.2408	**-0.1720**
	O3-2413	1.6525	1.6521	1.6523	1.6555	1.6559	1.6557	-0.0034	-3.40		14.2989	-0.2378	
	O3-2414	1.6308	1.6305	1.6307	1.6344	1.6341	1.6343	-0.0036	-3.60		14.1400	-0.2546	
	O3-2415	1.6126	1.6123	1.6125	1.6159	1.6158	1.6159	-0.0034	-3.40		14.0011	-0.2428	
	O3-2416	1.7066	1.7064	1.7065	1.6990	1.6992	1.6991	0.0074	7.40		14.2822	0.5181	
	O3-2417	1.7009	1.7002	1.7006	1.7044	1.7045	1.7045	-0.0039	-3.90		14.6618	-0.2660	
	O3-2388	1.6025	1.6024	1.6025	1.6053	1.6050	1.6052	-0.0027	-2.70		13.9946	-0.1929	
	O3-2389	1.6965	1.6965	1.6965	1.7001	1.7002	1.7002	-0.0036	-3.65		14.6474	-0.2492	
	O3-2390	1.6774	1.6776	1.6775	1.6811	1.6811	1.6811	-0.0036	-3.60		14.4181	-0.2497	
	O3-2391	1.7046	1.7048	1.7047	1.7084	1.7083	1.7084	-0.0036	-3.65		14.5902	-0.2502	
Clariant Safeway KF Hot	O3-2392	1.6422	1.6423	1.6423	1.6455	1.6454	1.6455	-0.0032	-3.20	**-3.23**	14.4387	-0.2216	**-0.2241**
	O3-2393	1.6210	1.6210	1.6210	1.6244	1.6237	1.6241	-0.0031	-3.05		14.0745	-0.2167	
	O3-2394	1.6722	1.6724	1.6723	1.6754	1.6755	1.6755	-0.0032	-3.15		14.5493	-0.2165	
	O3-2395	1.6615	1.6604	1.6610	1.6647	1.6647	1.6647	-0.0037	-3.75		14.4711	-0.2591	
	O3-2396	1.6571	1.6575	1.6573	1.6600	1.6599	1.6600	-0.0026	-2.65		14.2011	-0.1866	
	O3-2397	1.6869	1.6871	1.6870	1.6900	1.6898	1.6899	-0.0029	-2.90		14.6026	-0.1986	
	O3-2368	1.6081	1.6083	1.6082	1.6115	1.6113	1.6114	-0.0032	-3.20		22.4146	-0.1428	
	O3-2369	1.6995	1.6991	1.6993	1.7027	1.7026	1.7027	-0.0033	-3.35		23.0016	-0.1456	
	O3-2370	1.6103	1.6102	1.6103	1.6130	1.6130	1.6130	-0.0027	-2.75		14.1408	-0.1945	
	O3-2371	1.5953	1.5948	1.5951	1.5981	1.5981	1.5981	-0.0031	-3.05		14.0849	-0.2165	
Hydro Chemicals AVIFORM L50	O3-2372	1.7297	1.7296	1.7297	1.7330	1.7329	1.7330	-0.0033	-3.30	**-3.32**	14.8832	-0.2217	**-0.2121**
	O3-2373	1.7054	1.7052	1.7053	1.7091	1.7089	1.7090	-0.0037	-3.70		14.7498	-0.2509	
	O3-2374	1.6942	1.6944	1.6943	1.6976	1.6975	1.6976	-0.0033	-3.25		14.5452	-0.2234	
	O3-2375	1.7115	1.7115	1.7115	1.7153	1.7153	1.7153	-0.0038	-3.80		14.6991	-0.2585	
	O3-2376	1.7075	1.7075	1.7075	1.7109	1.7110	1.7110	-0.0034	-3.45		14.6219	-0.2359	
	O3-2377	1.6902	1.6900	1.6901	1.6935	1.6934	1.6935	-0.0033	-3.35		14.5236	-0.2307	

		Dry Weights			Final Weights			Weight Loss Due to Thermal	Weight Loss Due to Thermal	**Average Weight Loss Due to Thermal**	Total Surface	Weight Loss Per Surface Area	**Average Weight Loss Per Surface Area**
Deicer	Panel ID	Mass 1	Mass 2	Average	Mass 1	Mass 2	Average	Exposure (g)	Exposure (mg)	**Exposure (mg)**	Area (cm^2)	(mg/cm^2)	**(mg/cm^2)**
Deionized Water	O3-2468	1.6140	1.6139	1.6140	1.6162	1.6159	1.6161	-0.0021	-2.10	**-2.09**	22.0056	-0.0954	**-0.1392**
	O3-2469	1.7303	1.7299	1.7301	1.7330	1.7332	1.7331	-0.0030	-3.00		14.6820	-0.2043	
	O3-2470	1.6875	1.6878	1.6877	1.6899	1.6898	1.6899	-0.0022	-2.20		14.6416	-0.1503	
	O3-2471	1.7091	1.7030	1.7061	1.7052	1.7055	1.7054	0.0007	0.70		14.8128	0.0473	
	O3-2472	1.6949	1.6950	1.6950	1.6387	1.6385	1.6386	0.0563	56.35		14.6101	3.8569	
	O3-2473	1.6686	1.6683	1.6685	1.6710	1.6708	1.6709	-0.0025	-2.45		14.4092	-0.1700	
	O3-2474	1.5848	1.5859	1.5854	1.5878	1.5877	1.5878	-0.0024	-2.40		13.9730	-0.1718	
	O3-2475	1.6841	1.6842	1.6842	1.6870	1.6867	1.6869	-0.0027	-2.70		14.6032	-0.1849	
	O3-2476	1.6078	1.6081	1.6080	1.6100	1.6102	1.6101	-0.0022	-2.15		14.1985	-0.1514	
	O3-2477	1.6770	1.6772	1.6771	1.6794	1.6798	1.6796	-0.0025	-2.50		14.5253	-0.1721	
METSS ADF-2	O3-2428	1.6665	1.6690	1.6678	1.6704	1.6702	1.6703	-0.0026	-2.55	**-3.38**	14.3363	-0.1779	**-0.2402**
	O3-2429	1.6509	1.6506	1.6508	1.6537	1.6537	1.6537	-0.0030	-2.95		14.3559	-0.2055	
	O3-2430	1.7066	1.7066	1.7066	1.7102	1.7099	1.7101	-0.0034	-3.45		14.6859	-0.2349	
	O3-2431	1.6824	1.6824	1.6824	1.6857	1.6856	1.6857	-0.0032	-3.25		14.5444	-0.2235	
	O3-2432	1.6685	1.6684	1.6685	1.6718	1.6716	1.6717	-0.0032	-3.25		14.5397	-0.2235	
	O3-2433	1.7038	1.7039	1.7039	1.7076	1.7077	1.7076	-0.0038	-3.79		13.8176	-0.2746	
	O3-2434	1.6399	1.6400	1.6400	1.6438	1.6437	1.6438	-0.0038	-3.80		13.7550	-0.2763	
	O3-2435	1.6755	1.6753	1.6754	1.6788	1.6789	1.6789	-0.0035	-3.45		13.6561	-0.2526	
	O3-2436	1.6826	1.6827	1.6827	1.6862	1.6864	1.6863	-0.0036	-3.65		13.6305	-0.2678	
	O3-2437	1.6580	1.6581	1.6581	1.6617	1.6617	1.6617	-0.0037	-3.65		13.7486	-0.2655	
Battelle D^3	O3-2448	1.6915	1.6914	1.6915	1.6839	1.6838	1.6839	0.0076	7.60	**7.91**	14.6097	0.5202	**0.5239**
	O3-2449	1.7073	1.7073	1.7073	1.6995	1.6996	1.6996	0.0078	7.75		14.6002	0.5308	
	O3-2450	1.6627	1.6627	1.6627	1.6554	1.6553	1.6554	0.0074	7.35		14.3482	0.5123	
	O3-2451	1.6920	1.6917	1.6919	1.6843	1.6844	1.6844	0.0075	7.50		14.4804	0.5179	
	O3-2452	1.7295	1.7296	1.7296	1.7213	1.7212	1.7213	0.0083	8.30		14.7309	0.5634	
	O3-2453	1.6123	1.6124	1.6124	1.6051	1.6051	1.6051	0.0073	7.25		14.0803	0.5149	
	O3-2454	1.6591	1.6590	1.6591	1.6510	1.6509	1.6510	0.0081	8.10		14.1882	0.5709	
	O3-2455	1.7018	1.7018	1.7018	1.6934	1.6930	1.6932	0.0086	8.60		14.5873	0.5896	
	O3-2456	1.7295	1.7295	1.7295	1.7210	1.7209	1.7210	0.0085	8.55		23.3620	0.3660	
	O3-2457	1.7015	1.7014	1.7015	1.6935	1.6933	1.6934	0.0080	8.05		14.5687	0.5526	

977-3 Epoxy Resin

Date of Analysis: July 15, 2003

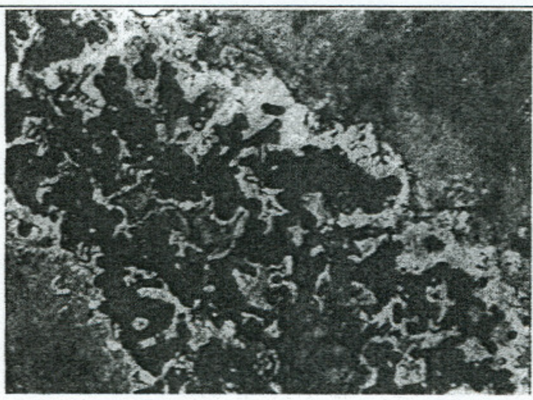
Deicer	Lab Sample ID	Percent Weight Gain	Average Percent Weight Gain
DI Water	03-4844-P	0.01	0.02
	03-4845-P	0.03	
METSS ADF-2	03-4840-P	0.28	0.38
	03-4841-P	0.48	
Battelle D(3)	03-4842-P	0.07	0.065
	03-4843-P	0.06	
METSS RDF-2	03-4838-P	0.53	0.52
	03-4839-P	0.51	
Safeway KF Hot	03-4836-P	0.33	0.39
	03-4837-P	0.45	
AVIFORM L50	03-4834-P	0.36	0.37
	03-4835-P	0.38	

5250-4 BM Resin

Date of Analysis: July 15, 2003

Deicer	Lab Sample ID	Percent Weight Gain	Average Percent Weight Gain
DI Water	03-4856-P	0.02	0.015
	03-4857-P	. 0.01	
METSS ADF-2	03-4852-P	0.43	0.515
	03-4853-P	0.6	
Battelle D(3)	03-4854-P	0.07	0.045
	03-4855-P	0.02	
METSS RDF-2	03-4850-P	0.65	0.56
	03-4851-P	0.47	
Safeway KF Hot	03-4848-P	0.28	0.285
	03-4849-P	0.29	
AVIFORM L50	03-4846-P	0.54	0.49
	03-4847-P	0.44	

Appendix B1
Polymer Matrix Composites – Sandwich Corrosion Graphics

 03-2278 ALUMINUM	977-3 Composite exposed to METSS RDF-2 Rated 4
 03-2405 GRAPHITE	5250-2 BM Resin exposed to METSS RDF-2 Rated 4

Appendix C
Elastomeric Materials

Elastomeric Materials – Percent Volume Swell Data

Nitrile Elastomer

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-1967-P	51	50	51	50.7	50	51	51	50.7	0.0
METSS ADF-2	03-1954-P	52	50	51	51.0	49	50	50	49.7	-2.6
Battelle D(3)	03-1961-P	51	52	50	51.0	51	51	52	51.3	0.7
METSS RDF-2	03-1947-P	50	51	50	50.3	50	50	49	49.7	-1.3
Safeway KF Hot	03-1940-P	51	50	49	50.0	50	51	50	50.3	0.7
AVIFORM L50	03-1933-P	51	50	50	50.3	51	51	51	51.0	1.3

Neoprene Elastomer

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-2008-P	56	56	56	56.0	56	55	57	56.0	0.0
METSS ADF-2	03-1995-P	56	56	56	56.0	55	56	56	55.7	-0.6
Battelle D(3)	03-2002-P	56	56	57	56.3	55	56	56	55.7	-1.2
METSS RDF-2	03-1988-P	56	55	56	55.7	56	56	55	55.7	0.0
Safeway KF Hot	03-1981-P	57	55	56	56.0	56	56	56	56.0	0.0
AVIFORM L50	03-1974-P	56	54	56	55.3	55	56	55	55.3	0.0

Polysulfide Sealant

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-2112-P	49	47	50	48.7	51	51	54	52.0	6.8
METSS ADF-2	03-2096-P	51	50	52	51.0	51	51	52	51.3	0.7
Battelle D(3)	03-2104-P	49	37	45	43.7	48	47	52	49.0	12.2
METSS RDF-2	03-2086-P	50	50	51	50.3	51	52	53	52.0	3.3
Safeway KF Hot	03-2078-P	49	50	49	49.3	54	54	53	53.7	8.8
AVIFORM L50	03-2069-P	52	51	50	51.0	55	54	54	54.3	6.5

Elastomeric Materials – Percent Volume Swell Data

High Temperature Polysulfide Sealant

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-2059-P	45	45	45	45.0	51	50	52	51.0	13.3
METSS ADF-2	03-2043-P	48	49	48	48.3	51	51	50	50.7	4.8
Battelle D(3)	03-2051-P	47	47	45	46.3	51	50	51	50.7	9.4
METSS RDF-2	03-2033-P	48	48	49	48.3	51	51	51	51.0	5.5
Safeway KF Hot	03-2025-P	48	50	48	48.7	52	52	51	51.7	6.2
AVIFORM L50	03-2015-P	51	51	50	50.7	53	50	52	51.7	2.0

Corrosion-Inhibiting Sealant

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-2165-P	33	34	33	33.3	39	40	39	39.3	18.0
METSS ADF-2	03-2149-P	32	33	32	32.3	38	39	39	38.7	19.6
Battelle D(3)	03-2157-P	35	34	32	33.7	40	38	40	39.3	16.8
METSS RDF-2	03-2139-P	31	34	32	32.3	39	38	41	39.3	21.6
Safeway KF Hot	03-2131-P	33	33	32	32.7	38	38	39	38.3	17.3
AVIFORM L50	03-2121-P	33	32	32	32.3	40	41	41	40.7	25.8

Polythioether Sealant

Sample	Sample ID	1st	2nd	3rd	Initial Hardness	1st	2nd	3rd	Final Hardness	% Difference
Unexposed	03-2219-P	49	48	48	48.3	54	55	53	54.0	11.7
METSS ADF-2	03-2201-P	47	50	47	48.0	49	53	48	50.0	4.2
Battelle D(3)	03-2211-P	53	52	50	51.7	43	54	52	49.7	-3.9
METSS RDF-2	03-2193-P	27	31	30	29.3	30	33	29	30.7	4.5
Safeway KF Hot	03-2183-P	33	29	28	30.0	34	33	32	33.0	10.0
AVIFORM L50	03-2175-P	52	34	51	45.7	55	40	51	48.7	6.6

Elastomeric Materials – Percent Volume Swell Data

Sample	Initial Weight (gm)	1st Length (in)	1st Wide (in)	1st Height (in)	Initial Volume (in3)	Final Weight (gm)	% Weight Change	2nd Length (in)	2nd Width (in)	2nd Height (in)	Final Volume (in3)
1934 EL 1, Avifrom L50	3.7745	1.591	1.000	0.125	0.1989	3.7743	-0.0053	1.584	0.999	0.125	0.1978
"	3.3536	1.392	0.997	0.125	0.1735	3.3532	-0.0119	1.406	0.999	0.126	0.1770
1941 EL 1, Safeway	3.2530	1.403	0.996	0.121	0.1691	3.2516	-0.0430	1.403	0.998	0.122	0.1708
“	3.7117	1.592	0.999	0.122	0.1940	3.7096	-0.0566	1.594	0.999	0.123	0.1959
1948 EL 1, RDF-2	3.3327	1.446	0.995	0.122	0.1755	3.3440	0.3391	1.445	0.998	0.122	0.1759
“	3.5966	1.555	0.996	0.122	0.1890	3.6036	0.1946	1.556	0.997	0.122	0.1893
1955 EL 1, ADF-2	3.4315	1.455	0.999	0.124	0.1802	3.4642	0.9529	1.450	1.000	0.125	0.1813
“	3.6327	1.542	0.999	0.124	0.1910	3.6702	1.0323	1.542	1.000	0.125	0.1928
1962 EL 1, D(3)	3.3526	1.421	1.000	0.125	0.1776	3.3573	0.1402	1.421	1.000	0.126	0.1790
“	3.7430	1.574	0.999	0.125	0.1966	3.7481	0.1363	1.575	1.000	0.125	0.1969
1968 EL 1, Unexposed	3.4666	1.466	0.998	0.124	0.1814	3.4668	0.0058	1.466	0.998	0.124	0.1814
“	3.6068	1.531	0.999	0.124	0.1897	3.6069	0.0028	1.531	0.999	0.123	0.1881
1975 EL 2, Avifrom L50	3.6392	1.490	1.000	0.118	0.1758	3.6374	-0.0495	1.490	1.000	0.118	0.1758
“	3.7272	1.513	1.000	0.117	0.1770	3.7248	-0.0644	1.513	1.000	0.117	0.1770
1982 EL 2, Safeway	3.7537	1.525	1.000	0.119	0.1815	3.7506	-0.0826	1.526	0.999	0.119	0.1814
“	3.6637	1.476	0.999	0.119	0.1755	3.6602	-0.0955	1.477	0.999	0.119	0.1756
1989 EL 2, RDF-2	3.7301	1.477	0.999	0.118	0.1741	3.7558	0.6890	1.478	0.998	0.119	0.1755
“	3.6735	1.521	1.000	0.118	0.1795	3.6954	0.5962	1.522	1.000	0.119	0.1811
1996 EL 2, ADF-2	3.6077	1.476	0.999	0.118	0.1740	3.6173	0.2661	1.477	0.999	0.118	0.1741
“	3.7083	1.519	1.000	0.119	0.1808	3.7220	0.3694	1.519	1.000	0.119	0.1808
2003 EL 2, D(3)	3.5908	1.467	1.000	0.118	0.1731	3.5950	0.1170	1.466	1.000	0.118	0.1730
“	3.7867	1.537	1.000	0.118	0.1814	3.7909	0.1109	1.537	0.999	0.118	0.1812
2009 EL 2, Unexposed	3.6962	1.503	0.999	0.118	0.1772	3.6964	0.0054	1.503	0.999	0.118	0.1772
“	3.6584	1.501	1.000	0.119	0.1786	3.6587	0.0082	1.501	1.000	0.119	0.1786

Elastomeric Materials – Percent Volume Swell Data

Sample	Initial Weight (gm)	1st Length (in)	1st Wide (in)	1st Height (in)	Initial Volume (in3)	Final Weight (gm)	% Weight Change	2nd Length (in)	2nd Width (in)	2nd Height (in)	Final Volume (in3)
2068 SL 1, Avifrom L50	3.1911	0.983	1.001	0.128	0.1259	3.1779	-0.4137	0.984	0.985	0.125	0.1212
"	3.5602	1.014	0.967	0.139	0.1363	3.5452	-0.4213	1.010	0.952	0.140	0.1346
2077 SL 1, Safeway	3.2496	1.017	0.980	0.126	0.1256	3.2377	-0.3662	0.974	1.010	0.125	0.1230
"	3.5099	0.990	0.959	0.142	0.1348	3.4952	-0.4188	0.993	0.971	0.141	0.1360
2087 SL 1, RDF-2	3.1799	0.953	0.980	0.130	0.1214	3.1725	-0.2327	0.951	0.984	0.127	0.1188
"	3.2622	0.987	0.996	0.127	0.1248	3.2567	-0.1686	0.970	0.991	0.126	0.1211
2095 SL 1, ADF-2	3.3906	1.003	0.990	0.132	0.1311	3.3801	-0.3097	0.999	0.989	0.131	0.1294
"	3.437	1.040	0.990	0.125	0.1287	3.4237	-0.3870	1.039	0.990	0.125	0.1286
2105 SL 1, D(3)	3.4244	1.017	0.994	0.128	0.1294	3.4135	-0.3183	1.017	0.999	0.130	0.1321
"	3.6242	0.984	1.029	0.136	0.1377	3.6132	-0.3035	0.995	1.021	0.137	0.1392
2113 SL 1, Unexposed	3.3672	1.020	0.974	0.129	0.1282	3.3491	-0.5375	1.019	0.966	0.128	0.1260
"	3.38	0.989	0.998	0.138	0.1362	3.3663	-0.4053	0.989	0.999	0.137	0.1354
2016 SL 2, Avifrom L50	3.1184	0.922	0.993	0.130	0.1190	3.1074	-0.3527	0.924	0.998	0.128	0.1180
"	3.009	0.921	1.001	0.127	0.1171	2.9977	-0.3755	0.923	1.001	0.126	0.1164
2024 SL 2, Safeway	3.1655	0.990	0.927	0.131	0.1202	3.1547	-0.3412	0.996	0.928	0.131	0.1211
"	3.0756	0.991	0.972	0.122	0.1175	3.0660	-0.3121	0.991	0.975	0.121	0.1169
2034 SL 2, RDF-2	3.3524	1.003	0.996	0.127	0.1269	3.3506	-0.0537	1.005	0.998	0.127	0.1274
"	3.3942	1.018	1.003	0.122	0.1246	3.3903	-0.1149	1.019	1.003	0.121	0.1237
2042 SL 2, ADF-2	3.0072	0.951	0.977	0.122	0.1134	2.9988	-0.2793	0.955	0.977	0.123	0.1148
"	3.6403	0.997	0.905	0.153	0.1380	3.6314	-0.2445	0.994	0.904	0.151	0.1357
2052 SL 2, D(3)	3.3644	1.003	0.990	0.134	0.1331	3.3565	-0.2348	1.006	0.992	0.132	0.1317
"	3.4288	0.963	0.996	0.133	0.1276	3.4223	-0.1896	0.973	0.997	0.134	0.1300
2060 SL 2, Unexposed	3.3898	1.005	0.978	0.131	0.1288	3.3772	-0.3717	1.006	0.979	0.131	0.1290
"	3.6208	1.001	0.962	0.143	0.1377	3.6100	-0.2983	1.000	0.962	0.142	0.1366

Elastomeric Materials – Percent Volume Swell Data

Sample	Initial Weight (gm)	1st Length (in)	1st Wide (in)	1st Height (in)	Initial Volume (in3)	Final Weight (gm)	% Weight Change	2nd Length (in)	2nd Width (in)	2nd Height (in)	Final Volume (in3)
2174 SL 4, Avifrom L50	3.8252	0.983	0.940	0.172	0.1589	3.7878	-0.9777	0.995	0.942	0.172	0.1612
“	3.4183	0.989	0.936	0.160	0.1481	3.3834	-1.0210	0.986	0.932	0.161	0.1480
2184 SL 4, Safeway	3.8338	0.992	1.010	0.162	0.1623	3.7952	-1.0068	0.980	1.008	0.160	0.1581
“	3.7798	0.991	0.996	0.164	0.1619	3.7402	-1.0477	0.995	0.993	0.161	0.1591
2192 SL 4, RDF-2	3.9746	0.997	1.035	0.163	0.1682	3.9652	-0.2365	0.994	1.032	0.163	0.1672
“	3.7872	1.031	0.994	0.161	0.1650	3.7817	-0.1452	1.026	0.991	0.160	0.1627
2202 SL 4, ADF-2	4.1688	0.981	1.047	0.171	0.1756	4.1415	-0.6549	0.974	1.043	0.170	0.1727
“	4.7559	1.017	0.997	0.197	0.1997	4.7172	-0.8137	1.017	0.998	0.196	0.1989
2210 SL 4, D(3)	3.9622	0.976	0.981	0.171	0.1637	3.9390	-0.5855	0.973	0.981	0.170	0.1623
“	3.9179	0.979	0.965	0.175	0.1653	3.8892	-0.7325	0.980	0.964	0.174	0.1644
2218 SL 4, Unexposed	4.2946	1.015	1.010	0.181	0.1856	4.2468	-1.1130	1.017	1.012	0.180	0.1853
“	4.1676	0.952	1.007	0.183	0.1754	4.1229	-1.0726	0.950	1.006	0.183	0.1749
2122 SL 3, Avifrom L50	7.1310	1.968	0.975	0.160	0.3070	7.0980	-0.4628	1.948	0.966	0.159	0.2992
“	6.4264	1.991	0.961	0.149	0.2851	6.3954	-0.4824	1.983	0.953	0.148	0.2797
2130 SL 3, Safeway	6.4335	1.975	0.986	0.131	0.2551	6.4067	-0.4166	1.968	0.970	0.131	0.2501
“	6.7479	1.998	0.993	0.141	0.2797	6.7226	-0.3749	1.980	0.978	0.140	0.2711
2140 SL 3, RDF-2	6.5957	2.004	0.992	0.135	0.2684	6.6187	0.3487	1.989	0.983	0.135	0.2640
“	7.1668	1.982	0.966	0.158	0.3025	7.1877	0.2916	1.962	0.952	0.157	0.2932
2148 SL 3, ADF-2	7.6506	1.982	0.981	0.160	0.3111	7.6531	0.0327	1.963	0.968	0.160	0.3040
“	7.7768	1.995	0.978	0.169	0.3297	7.7834	0.0849	1.974	0.961	0.168	0.3187
2158 SL 3, D(3)	6.8700	1.975	1.003	0.144	0.2853	6.8472	-0.3319	1.959	0.986	0.143	0.2762
“	7.2015	1.997	1.002	0.145	0.2901	7.1770	-0.3402	1.979	0.992	0.144	0.2827
2166 SL 3, Unexposed	7.7337	1.981	1.017	0.153	0.3082	7.9387	2.6507	1.964	1.011	0.153	0.3038
“	7.9436	2.005	1.013	0.158	0.3209	8.1796	2.9709	1.994	1.004	0.158	0.3163

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-S-8802

Issued Proposed Draft 1998-04

Submitted for recognition as an American National Standard

Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion

FOREWORD

This document is based on MIL-S-8802F, Amendment 4.

1. SCOPE:

1.1 Form:

This specification covers temperature resistant, two component synthetic rubber compounds of the polysulfide type for sealing and repairing integral fuel tanks and fuel cell cavities, for continuous service use from -65 to +250 °F (-54 to 121 °C).

1.2 Application:

This sealing compound has been used typically for fuel tank sealing, cabin pressure sealing, and aerodynamic smoothing, but usage is not limited to such applications. It can be used for faying surface sealing, for wet-installation of fasteners, for overcoating fasteners, and for sealing joints and seams. The sealing compound can be used in fuel areas as well as in non-fuel areas. It may in some cases be used as a non-structural adhesive. It cures at room temperature and the cure can be accelerated by higher temperatures. AMS 3100 adhesion promoter can be applied prior to application of the sealant.

1.3 Classification:

Sealing compounds covered by this specification are classified by method of application and application times as follows:

Class A - Suitable for brush application. Available in the following application times in hours:

a. A-1/2
b. A-1
c. A-2

1.3 (Continued):

Class B - Suitable for application by extrusion gun, spatula, brush, or roller. Available in the following application times in hours:

a. B-1/2
b. B-1
c. B-2
d. B-4

Class C - Suitable for extrusion gun, spatula, brush, or roller. Available in the following application times in hours:

a. C-12
b. C-20
c. C-80
d. C-96

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. Unless otherwise specified, the applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2471 Anodic Treatment of Aluminum Alloys, Sulfuric Acid Process, Undyed Coating
AMS 2629 Fluid, Jet Reference
AMS 3100 Adhesion Promoter, for Polysulfide Sealing Compounds
AMS 3276 Sealing Compound, Integral Fuel Tanks and General Purpose, Intermittent Use to 360 °F (182 °C)
AMS 3819 Cloths, Cleaning for Aircraft Primary and Secondary Structural Surfaces
AMS 4045 Aluminum Alloy Sheet and Plate, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (7075; -T6 Sheet/-T651 Plate), Solution and Precipitation Heat Treated
AMS 4049 Aluminum Alloy Sheet and Plate, Alclad, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (Alclad 7075; -T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS 4901 Titanium, Sheet, Strip and Plate, Annealed, 70,000 psi (485 Mpa) Yield Strength

2.1 (Continued):

AMS 5516	Steel, Corrosion Resistant, Sheet, Strip, and Plate, 18Cr - 9.0Ni, (SAE 30302) Solution Heat Treated
AS5127	Methods for Testing Aerospace Sealants (May, 1997. See 4.5.3.1)
AS5127/1	Methods for Testing Aerospace Sealants, Two-Component Synthetic Rubber Compounds (May, 1997. See 4.5.3.1)
AS7001	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Program Description
AS7002	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Rules for Implementation
AS7003	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Program Operation
AS7200/1	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Audit and Inspection Procedures and Checklists for the Sealant Manufacturers Accreditation Program
AS7201	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Requirements for Accreditation of Pass-Thru Distributors
AS7202	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Requirements for Accreditation of Value Added Distributors
PD 2000	Procedures for an Industry Qualified Product Management Process

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 1974 Methods for Closing, Sealing, and Reinforcing Fiberboard Boxes

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

PPP-C-96	Can, Metal, 28 Gage and Lighter
PPP-D-729	Drum, Shipping and Storage, Steel, 55 Gallon (208 Liters)
PPP-P-704	Pails, Metal: (Shipping, Steel, 1 through 12 Gallons)
MIL-S-8802	Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-P-23377	Primer Coatings: Epoxy, High Solids
MIL-C-27725	Coating, Corrosion Preventive, for Aircraft Integral Fuel Tanks
MIL-S-38714	Sealant Cartridge for Two Component Materials
MIL-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

The basic ingredient used in the manufacture of these products shall be synthetic rubber of the polysulfide (T) type. The sealing compound shall cure by the addition of a curing agent to the base compound, and shall not depend on solvent evaporation for curing. The material shall contain no lead compounds or chromate compounds. The curing agent shall possess sufficient color contrast to the base compound to permit easy identification of an unmixed or incompletely mixed sealing compound. Neither the base compound nor the cured sealant shall be red or pink in color.

3.2 Properties:

The sealing compound and the curing agent shall conform to the requirements shown in Table 1, when tested to the specified test methods.

3.3 Performance and Application Requirements:

Performance requirements define those properties of the cured sealant related to performance in service. Application requirements define those properties of the uncured sealant which affect the application parameters of the sealant, but have little or no effect on performance properties of the cured sealant. Minor variations in the Application requirements during quality conformance inspection such as receiving inspection tests, may not be cause for rejection if approved by the purchaser. Application requirements are listed below; all other properties are Performance requirements.

a. Viscosity of Base Compound
b. Flow
c. Application Time
d. Tack-Free Time
e. Cure Time
f. Fluid Immersion Cure Time

TABLE 1 - Properties

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.1	Specific Gravity, max	1.65	(6.1)
3.3.2	Nonvolatile Content, by weight, min		(5.1)
	Class A	84%	
	Class B	92%	
	Class C	92%	
3.3.3	Viscosity of Base Compound		(5.3)
	Class A	100 to 500 poises (10 to 50 Pa·S)	Use No. 6 spindle at 10 RPM
	Class B	9000 to 14000 poises (900 to 1400 Pa·S)	Use No. 7 spindle at 2 RPM
	Class C	1000 to 4000 poises (100 to 400 Pa·S)	Use No. 6 spindle at 2 RPM
3.3.4	Flow		
	Class B	0.1 to 0.75 inch (2.5 to 19.1 mm)	(5.5.1)
	Class C	0.010 inch (0.25 mm) min	(5.5.2)
3.3.5	Application Time, min		
3.3.5.1	Class A - From beginning of mixing, the viscosity shall not exceed 2,500 poises (250 Pa·s)		(5.6.1) Use No. 7 spindle at 10 rpm
	A-1/2	1/2 hour	
	A-1	1 hour	
	A-2	2 hours	

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.5.2	Class B - From beginning of mixing, 15 grams per minute (minimum) shall be extruded		(5.6.2)
	B-1/2	1/2 hour	
	B-1	1 hour	
	B-2	2 hours	
	B-4	4 hours	
3.3.5.3	Class C - From beginning of mixing, 30 grams per minute (minimum) shall be extruded		(5.6.2)
	C-12	4 hours	
	C-20	8 hours	
	C-80	8 hours	
	C-96	8 hours	
3.3.6	Assembly Time (or Squeeze-out Time), min		(5.7)
	Class C-12	12 hours	
	Class C-20	20 hours	
	Class C-80	80 hours	
	Class C-96	96 hours	
3.3.7	Tack-free Time (Measured from beginning of mixing) Max		(5.8)
	Class A-1/2	10 hours	
	Class A-1	20 hours	
	Class A-2	40 hours	
	Class B-1/2	10 hours	
	Class B-1	20 hours	
	Class B-2	40 hours	
	Class B-4	48 hours	
	Class C-12	No requirement	
	Class C-20	96 hours	
	Class C-80	120 hours	
	Class C-96	No requirement	

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.8	Standard Cure Time, Max (30 Durometer A, min)		(5.9)
	Class A-1/2	40 hours	
	Class A-2	72 hours	
	Class B-1/2	30 hours	
	Class B-1	55 hours	
	Class B-2	72 hours	
	Class B-4	90 hours	
3.3.9	Fluid Immersion Cure Time, min (Class A-1/2 and B-1/2 only)		(5.11)
	After 48 hours	25 Durometer A	
	After 120 hours	35 Durometer A	
3.3.10	Peel Strength, min /100% cohesive failure		(8.1) and Table 4
3.3.10.1	Class A and B:		
	After 7 day exposure	20 lbf/inch (3580 N/m)	
	After 70 day exposure	7 lbf/inch (1250 N/m)	
3.3.10.2	Class C:		
	After 7 day exposure	15 lbf/inch (2685 N/m)	
	After 70 day exposure	7 lbf/inch (1250 N/m)	
3.3.10.3	Classes A-1/2 and B-1/2 only	10 lbf/inch (1750 N/m)	(8.1.3)
3.3.10.4	Repairability, min /100% cohesive failure	10 lbf/inch (1750 N/m)	(8.2) on itself and AMS 3276
3.3.11	Chalking, max Use AMS 2629 Type II JRF	Slight chalking	(7.1)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.12	Shear Strength (Class C only), min, /95% cohesive failure	200 psi (1379 kPa)	(7.8)
3.3.13	Air Content, (Class B only), max	4%	(5.2)
3.3.14	Weight Loss and Flexibility		(7.4)
3.3.14.1	Weight Loss, max	8%	
3.3.14.2	Flexibility	No cracking or checking	
3.3.15	Resistance to Thermal Rupture	No blistering or sponging, 0.125 inch (3 mm) deformation, max	(7.2)
3.3.16	Tensile Strength and Elongation, (Class B only) min		(7.7)
3.3.16.1	Standard Cure	200 psi (1380 kPa), 200% elong.	
3.3.16.2	After 14 days immersion in AMS 2629, Type I JRF at 140 °F (60 °C)	50 psi (345 kPa), 200% elong.	
3.3.16.3	After 7 days at 250 °F ± 5 (121 °C ± 3)	125 psi (862 kPa), 100% elong.	
3.3.16.4	After 72 hour immersion in AMS 2629, Type I JRF at 140 °F (60 °C), followed by 72 hour air-drying at 120 °F (55 °C) followed by 7 days air-aging at 250 °F ± 5 (121 °C ± 3)	200 psi (1380 kPa), 75% elong.	
3.3.16.5	After 24 hour at 250 °F ± 5 (121 °C ± 3), followed by 7 days immersion in AMS 2629, Type I JRF at 140 °F (60 °C)	100 psi (690 kPa), 150% elong.	

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.17	Low Temperature Flexibility	No visual evidence of cracking or checking. No loss of adhesion	(7.6)
3.3.18	Hydrolytic Stability, min	30 Durometer A	(6.6)
3.3.19	Corrosion	No signs of corrosion or deterioration	(7.9)
3.3.20	Radiographic Density		(6.3)
3.3.20.1	Difference between plate and plate sealant, max	1.00	
3.3.20.2	Through sealant in the slot, approximately	3.00	
3.3.21	Storage Stability		
3.3.21.1	Accelerated Storage		(9.1)
	Appearance	No skinning, hardening or separation that cannot be restored by normal agitation	
	Flow	Same as 3.3.4	
	Application Time	Same as 3.3.5	
	Assembly Time	Same as 3.3.6	
	Tack-Free Time	Same as 3.3.7	
	Standard Cure Time	Same as 3.3.8	
	Peel Strength, MIL-C-27725 Type II Class B (see 8.5) coated panels After 7 days immersion in AMS 2629, Type I JRF at 140 °F (60 °C)	Same as 3.3.10	
3.3.21.2	Long-Term Storage		(9.2)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	AS5127/1 Standard Test Method (paragraph)
3.3.21.2.1	Appearance	No skinning, hardening or separation that cannot be restored by normal agitation	
3.3.21.2.2	Application Time, hours, min		
	Class A-1/2	1/2	
	Class A-1	1	
	Class A-2	2	
	Class B-1/2	1/2	
	Class B-1	1	
	Class B-2	2	
	Class B-4	4	
	Class C-12	8	
	Class C-20	8	
	Class C-80	8	
	Class C-96	8	
3.3.21.2.3	Tack-Free Time, hours, max		
	Class A-1/2	16	
	Class A-1	30	
	Class A-2	64	
	Class B-1/2	16	
	Class B-1	30	
	Class B-2	64	
	Class B-4	72	
	Class C-12	No requirement	
	Class C-20	144	
	Class C-80	184	
	Class C-96	No requirement	
3.3.21.2.4	Standard Cure Time, hours, max		
	Class A-1/2	64	
	Class A-1	78	
	Class A2	112	
	Class B-1/2	45	
	Class B-1	78	
	Class B-2	112	
	Class B-4	136	

3.4 Quality:

The sealing compound and the curing agent (accelerator), as received by purchaser, shall be of uniform blend, and shall be free of excessive air, skins, lumps, and gelled or coarse particles. There shall be no separation of ingredients that cannot be readily dispersed.

3.5 Shelf Life:

Material shall be capable of meeting all the requirements of this specification after storage in original unopened package at 80 °F or lower for 9 months from date of packaging.

3.5.1 Date of Packaging: Date of Packaging is defined as the date finished material is assembled from its components, base compound and curing agent, into a package and labeled kit or unit by the manufacturer or repackager. Date of Packaging shall be no more than 90 days from the last day of full quality conformance testing in accordance with 4.3.3. Material may be retested by the manufacturer at any time to determine conformance to full quality conformance testing in accordance with 4.4.2.

3.5.2 Premixed and Frozen Material: Premixed and frozen material shall have a minimum storage life of 30 days at -40 °F (-40 °C) or lower, or 10 days at -10 to -40 °F (-23 to -40 °C) from date of mix/ freeze. The date of mix/freeze shall be within the shelf life of the unmixed material.

3.6 Qualification:

All products sold to this specification shall be listed, or approved for listing on the qualified products list, PRI QPL AMS-S-8802. The qualified products list shall be in accordance with PD 2000.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the sealing compound shall supply all samples and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the sealing compound conforms to the requirements of this specification.

4.1.1 Source Inspection: Material procured under this specification shall be third party approved prior to shipment, to ensure that material meets acceptance tests (4.3.3). Third party approval shall be by a third party accreditation process in accordance with AS7001, AS7002, AS7003, and AS7200/1. Sealant shall be from a manufacturer that currently holds a third party accreditation and shall be from a batch of material that has been third party source inspected in accordance with AS7200/1. Distributors supplying sealant shall supply material from an accredited manufacturer and from a batch of material that has been third party source inspected. Distributors shall also be third party accredited in accordance with AS7201 or AS7202, whichever is applicable.

NOTE—4.4.2 requires the sample for quality conformance tests be packaged and mixed as much as practical in the same containers that are being procured.

4.1.2 Shelf Life Surveillance and Updating:

4.1.2.1 Sampling: The minimum number of samples to be tested during shelf-life surveillance and updating is shown in Table 2.

TABLE 2 - Sampling

Items in Stock	Samples to be Tested
Up to 100, excl	3
100 to 500, incl	5
Over 500	7

4.1.2.2 Testing: The following inspections are to be conducted for shelf-life surveillance and updating:

a. Appearance
b. Application Time
c. Tack-Free Time
d. Standard Cure Time
e. Viscosity of Base Compound (not possible with sectional-type containers)
f. Peel Strength - two aluminum panels coated with MIL-C-27725 Type II Class B corrosion preventive coating (See 8.5), age in AMS 2629, Type I JRF for seven days at 140 °F (60 °C).

4.1.2.2.1 Tests are to be conducted in accordance with test methods outlined in this specification for acceptance tests. If the tests are being performed at the end of the stated shelf-life to update the shelf life of the sealing compound, and all tests are passed, the shelf life will be extended an additional three months. Up to three extensions will be allowed.

4.1.3 Curing Agent Replacement: There may be instances when the mixed sealant requires excessive time to cure. Occasionally, the curing agent is found to have deteriorated. It may be possible to replace the curing agent so that the base compound can be used. Whenever the curing agent is replaced, all acceptance tests must be met by the final curing agent/base compound combination.

4.2 Classification of Tests:

4.2.1 Qualification Tests: All technical requirements are qualification tests (See 8.1) and shall be performed prior to the initial shipment of sealing compound to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.1.1 Class B-2 shall be the first material that is qualified for each supplier of sealing compound (See 8.1). Class B-2 sealing compound shall meet all technical requirements of this specification with the exception of requirements applicable to other classes.

4.2.1.2 Once qualification for Class B-2 is obtained, other classes may be qualified. The formulation for other classes, and for other Class B materials, shall be the same as Class B-2, except for minor variations necessary for conformance to viscosity and application time requirements. Qualification tests for other classes shall at a minimum consist of all acceptance tests (4.3.3) plus all peel strength tests listed in Table 4.

4.2.1.3 The manufacturer shall present written proof to the purchaser that all requirements are met prior to requesting qualification approval for any class. This includes assurance that the sealant will cure at standard conditions. Acceptance testing is conducted on sealant cured at 140 °F (60 °C). After the sealing compound has been accepted for qualification, approval will be granted and the sealant will be identified by reference to the manufacturer's code or formula number.

4.2.2 Qualification Test Samples: Samples shall consist of eight 1 quart (1 L) kits and three 1 pint (1/2 L) kits of sealing compound upon which qualification is desired. Samples shall be identified as specified herein and forwarded to the activity responsible for qualification testing as designated in the letter of authorization from that activity (See 8.1).

Samples for qualification tests:

SEALING COMPOUND, TEMPERATURE RESISTANT, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
Class and Dash Number
AMS-S-8802
Manufacturer's Code Number
Name of Manufacturer
Submitted by (name) (date) for qualification tests in accordance with AMS-S-8802 under authorization (reference authorizing letter)
Mixing instructions

4.3 Acceptance Tests:

4.3.1 Batch and Lot: A batch shall be defined as the quantity of material run through a mill or mixer at one time. A lot shall be defined as material from one batch of each component assembled (packaged) as finished product in one size and/or type of container at the same time. The lot, when used, shall be traceable to the batches of base compound and curing agent.

4.3.2 Contractor Initial and Final Acceptance Tests: Each batch shall be subjected to both initial and final acceptance testing. Sufficient material for initial acceptance testing shall be packaged in the same type containers that are being procured. Initial acceptance tests are those listed in 4.3.3. Final acceptance testing is to be conducted on the final packaged product and consists of Application Time, Tack-Free Time, Standard Cure Time, and Air Content (Class B only), premixed and frozen material excluded.

4.3.2.1 Sampling for Initial Acceptance Tests: The sample material shall be packaged for the initial acceptance testing in the same type containers that are being procured.

4.3.2.1.1 Plastic Injection Kits: If material is being procured in plastic injection kits, such as those conforming to MIL-P-38714, all tests shall be conducted on material that has been packaged and mixed in the initial sample injection kits except for Viscosity of Base Compound. During filling of initial sample kits, base compound and curing agent shall be placed in 1-quart (1-L) cans for the viscosity tests. If more than one size of injection kits are to be packaged from a particular batch, it is necessary to test material from only one size kit.

4.3.2.1.2 Cans, Pails, and Drums: If the material is being procured in cans, pails, or drums, the batch shall be tested on material placed in 1-quart (1-L) cans.

4.3.2.1.3 Both Type Containers: If the material is being procured in both types of containers, the initial acceptance tests shall be conducted on material packaged in plastic injection kits.

4.3.2 Sampling for Final Acceptance Tests: After successful completion of initial acceptance tests, the batch shall be released for final packaging. During packaging, test kits shall be picked at random to perform the following final acceptance tests:

a. Application Time (3.3.5)
b. Tack-Free Time (3.3.7)
c. Standard Cure Time (3.3.8)
d. Air Content (Class B only) (3.3.13)

4.3.3 Acceptance Tests: Acceptance tests of individual batches shall consist of the following:

a. Nonvolatile Content (3.3.2)
b. Viscosity of Base Compound[1] (3.3.3)
c. Flow (Classes B and C only) (3.3.4)
d. Application Time (3.3.5)
e. Assembly Time (Class C only) (3.3.6)
f. Tack-Free Time (3.3.7)
g. Standard Cure Time (Classes A and B only) (3.3.8)
h. Fluid Immersion Time (Classes A-1/2 and B-1/2 only (3.3.9)
i. Resistance to Thermal Rupture (Fluid Immersed only)[2] (3.3.15)
j. Shear Strength (Class C only)[2] (3.3.12)
k. Peel Strength (4 aluminum panels, AMS 4045, sulfuric acid anodized in accordance with AMS 2471 and coated with MIL-C-27725 Type II Class B only (See 8.5) (7 day immersion only). Do not use AMS 3100 adhesion promoter.[2] (3.3.10)
l. Chalking[2] (3.3.11)
m. Air Content (Class B only) (3.3.13)

1. Acceptance testing of Viscosity of Base Compound shall be conducted on material in 1-quart or 1-liter cans regardless of type of packaging being procured.
2. In lieu of 14-day cure specified, specimens shall be subjected to an accelerated cure of 48 hours at standard conditions followed by 24 hours at 140 °F (60 °C). Class C-80 shall be cured 48 hours at standard conditions followed by 48 hours at 140 °F (60 °C).

4.4 Approval:

4.4.1 Sealing compound supplied to this specification shall be listed, or approved for listing, on the qualified products list, PRI QPL AMS-S-8802.

4.4.2 Manufacturer shall use ingredients, manufacturing procedures, processes, and methods of inspection on production product which are essentially the same as those used on the approved sample. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures, manufacturer shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample product. Production product made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Standard Conditions: Standard laboratory conditions shall be 77 °F ± 2 (25 °C ± 1) and 50% ± 5 relative humidity. Except as otherwise specified herein, all test specimens shall be cured under these conditions. Test specimens shall be prepared at 77 °F ± 5 (25 °C ± 3) and immediately upon completion of preparation, shall be placed into standard conditions for cure. Except as otherwise specified herein, tests shall be performed at 77 °F ± 5 (25 °C ± 3).

4.5.1.1 Standard Tolerances: Unless otherwise specified herein, standard tolerances of AS5127 under (3.1) "Standard Tolerances" shall apply.

4.5.2 Preparation of Test Specimens: Test panel configuration shall be in accordance with AS5127/1 under (8.) "Peel Strength Properties" and (8.1) "Peel Strength Testing" and as in figures for either (Figure 23) "Four-Inch Peel Specimen Configuration" or (Figure 22) "Five-Inch Peel Specimen Configuration".

4.5.2.1 Cleaning of Test Panels: Test panels shall be cleaned in accordance with Table 3 and methods in accordance with AS5127.

NOTE—When organic coatings are specified for the test panels, the coatings shall be fully cured as defined by the applicable coating specification before cleaning. The applied coatings shall be at least 14 days old and a maximum of 6 months old stored at ambient indoor temperatures.

TABLE 3 - Cleaning of Test Panels

Panel Material	Cleaning Method, AS5127 (paragraph)
Aluminum alloy, chemical conversion coating test surface	(6.1) "Chemical Conversion Coating Application", including subparagraphs: (6.1.1) "Preparation of Aluminum Panel Test Surfaces" (6.1.2) "Chemical Conversion Coating" (6.1.2.1) "Panel Preparation" (6.1.2.2) "Coating Application (Immersion)"
Aluminum alloy, sulfuric acid anodized	(6.1.1) "Preparation of Aluminum Panel Test Surfaces"
AMS 5516 Stainless steel	(6.3) "Preparation of AMS 5516 Stainless Steel Panel Test Surfaces"
AMS 4901 Titanium alloy	(6.4) "Preparation of AMS 4901 Titanium Panel Test Surfaces"
Aluminum alloy, MIL-C-27725 Type II Class B (See 8.5) test surface	(6.2.1.1) "Cleaning of MIL-C-27725 Surface for Sealing"
Graphite epoxy composite AS4/3501-6	(6.5.1) "Cleaning of AS 4/3501-6, IM7/5250-4 and Other Composite Surfaces"
Aluminum alloy, MIL-P-23377 test surface	(6.2.2) "Cleaning of MIL-P-23377 Surface for Sealing"

4.5.2.2 Curing of the Sealing Compound: Shall be tested in accordance with AS5127 under (6.9) "Curing of the Sealing Compounds". For qualification testing, the sealing compound shall be cured for 14 days at Standard Conditions. For Acceptance testing, the sealing compound shall be given an accelerated cure for 48 hours minimum at Standard Conditions followed by 48 hours at 140 °F (60 °C).

4.5.3 Standard Test Methods: Standard Test Methods are in accordance with AS5127/1. In the event of a conflict between the text of this document and AS5127 and/or AS5127/1, the text of this document takes precedence.

4.5.3.1 Future Revisions of AS5127 and AS5127/1: Use of a specific issue of AS5127 and of AS5127 is for clarity. Future revisions of AS5127 and AS5127/1, when published, may be used providing test methods correspond in kind to those of the issues listed in 2.1.

NOTE—The coating should not be more than 48 hours old before sealant application.

TABLE 4 - Peel Strength Panels

Quantity Required	Panel Thickness Inch (mm)	Panel Material	Immersion Media at 140 °F (60 °C)
4 (Note 1)	0.040 (1.02)	Al alloy AMS 4045, chemical conversion coating per MIL-C-81706, Class 1A, Form II, Method C	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into AMS 2629, Type I JRF/salt water for 7 days
4	0.040 (1.02)	Al alloy AMS 4045, -T6, sulfuric acid anodized per AMS 2471	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into AMS 2629, Type I JRF/salt water for 7 days
4	0.025-0.040 (0.64-1.02)	Stainless steel AMS 5516	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into AMS 2629, Type I JRF/salt water for 7 days
4	0.025-0.040 (0.64-1.02)	AMS 4901 Titanium alloy	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into AMS 2629, Type I JRF/salt water for 7 days
6	0.040 (1.02)	Al alloy AMS 4045 sulfuric acid anodized per AMS 2471, 0.001 inch (0.025 mm) overcoat of MIL-C-27725 Type II Class B (See 8.5). Apply the manufacturer's primer.	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into equal parts AMS 2629, Type I JRF and 3% aqueous Sodium Chloride for 7 days 2 panels into AMS 2629, Type I JRF for 70 days with fluid change every 14 days
4	0.040 (1.02)	Al alloy AMS 4045 sulfuric acid anodized per AMS 2471, 0.001 inch (0.025 mm) overcoat of MIL-C-27725 Type II Class B (See 8.5). Apply the manufacturer's primer. Before sealant application, topcoat shall be cleaned and adhesion promoter per AMS 3100 applied.	2 panels into AMS 2629, Type I JRF for 7 days 2 panels into AMS 2629, Type I JRF/salt water for 7 days
8	0.040 (1.02)	Graphite epoxy composite AS 4/3501-6	2 panels into AMS 2629, Type I JRF for 7 days (2 peel ply side, 2 tool side) 2 panels into AMS 2629, Type I JRF/salt water for 7 days (2 peel ply side, 2 tool side)

TABLE 4 - Peel Strength Panels (Continued)

Quantity Required	Panel Thickness Inch (mm)	Panel Material	Immersion Media at 140 °F (60 °C)
8	0.040 (1.02)	Al alloy AMS 4045 sulfuric acid anodized per AMS 2471, 0.001 inch (0.025 mm) overcoat of MIL-P-23377 primer:	4 panels into salt water for 7 days 2 panels R.T. cured, 2 panels 200 °F (95 °C) cured.
		4 panels cured 7 days at standard conditions (R.T.), 4 panels with primer, cured 2 hours at 200 °F (95 °C).	4 panels into distilled water for 7 days: 2 panels R.T. cured, 2 panels 200 °F (95 °C) cured.

4.6 Reports:

The supplier of sealing compound shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, batch number, AMS-S-8802, Class and Dash Number, and manufacturer's identification. Test reports shall be stamped by the third part source inspection.

4.7 Resampling and Retesting:

If any specimen used in the above tests fails to meet specified requirements, disposition of the sealing compound may be based on the results of testing three additional specimens for each nonconforming specimen. Failure of any retest specimen to meet specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging:

5.1.1 Sealing compound shall be furnished in individual containers for the base compound and the curing agent or in sectional containers. The ratio of the quantity contained in the base compound container to the quantity contained in the curing agent container shall be the same as the recommended mixing ratio of the base compound to the curing agent. Adhesion promoter shall be packaged with the sealing compound.

5.1.2 Individual Containers: The base compound shall be furnished in 0.5-pint (236 mL), 1-pint (473 mL) 1-quart (946 mL), or 1-gallon (3.78 L) metal cans conforming to PPP-P-704, in 5-gallon (19 L) pails, in 55-gallon (208 L) drums conforming to PPP-D-729, Type III, except that tin plate cans with paper labels may be used or as specified in the purchase order. The air in the base compound containers shall be replaced with nitrogen immediately prior to closing the containers. The base compound contained in each container shall be as shown in Table 5.

TABLE 5 - Container Content

Size of Container	Amount of Base Compound
0.5 pint (236 mL)	6 fluid ounces ± 0.125 (178 mL ± 4)
1 pint (473 mL)	12 fluid ounces ± 0.25 (355 mL ± 7)
1 quart (946 mL)	24 fluid ounces ± 0.5 (710 mL ± 15)
1 gallon (3.78 L)	96 fluid ounces ± 2 (2.84 L ± 0.06)
5 gallon (19 L)	5 gallons ± 10 fluid ounces (19 L ± 0.3)
55 gallons (208 L)	50 gallons ± 0.5 (189 L ± 2)

5.1.2.1 The curing agent for kits 1 gallon (3.78 L) or under shall be furnished in glass jars or in suitable containers approved by the purchaser. Glass jars or plastic containers, as applicable, shall have vertical, smooth inside walls with no internal projections or internal lips exceeding 0.062 inch (1.57 mm). The glass jars shall be closed with enameled metal or plastic continuous thread screw caps having a nonabsorbent lining material. Caps shall be tightened adequately and further sealed with cellulose bands, or equivalent. Curing agent for 5-gallon (19 L) pails shall be packaged in 1-gallon (3.78 L) cans conforming to PPP-C-96, Type 5, Class 2. Curing agent for 55-gallon (208 L) drums shall be packaged in pails conforming to PPP-P-704.

5.1.2.2 One container each of the base compound and the curing agent, individually packaged in accordance with the foregoing, shall be enclosed in a fiberboard container in accordance with ASTM D 1974 and shall constitute a complete kit.

5.1.3 Sectional-Type Containers: The base compound and the curing agent shall be furnished in high-density polyethylene sectional-type 2.5 ounce (74 mL) or 6 ounce (178 mL) cartridges, conforming to MIL-S-38714, as specified in the purchase order. The total content of the base compound and the curing agent contained in each sectional container shall be as shown in Table 6.

TABLE 6 - Containers of Sectional-Type Containers

Size of Container	Total Content (Base and Curing)
2.5 ounces (74 mL)	2.0 fluid ounces ± 0.125 (59 mL ± 4)
6 ounces (178 mL)	3.5 fluid ounces ± 0.125 (104 mL ± 4)
8 ounces (237 mL)	6.0 fluid ounces ± 0.125 (178 mL ± 4)

5.1.4 Containers of compound shall be prepared for shipment in accordance with commercial practice and in accordance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the compound to ensure carrier acceptance and safe delivery.

5.2 Identification:

5.2.1 Each container and each box shall be permanently and legibly marked with not less than the following:

SEALING COMPOUND, TEMPERATURE RESISTANT, INTEGRAL FUEL TANKS AND FUEL CELL CAVITIES, HIGH ADHESION
Class and Dash Number
AMS-S-8802
MANUFACTURER'S NAME ______________________________
MANUFACTURER'S PRODUCT DESIGNATION ______________________________
BATCH NUMBER ______________________________
DATE OF PACKAGING ______________________________
SHELF LIFE EXPIRATION DATE ______________________________
STORE BELOW 80 °F (27 °C)

5.2.2 Shipping Containers: Each exterior shipping container shall be marked with not less than the following:

SEALING COMPOUND, TEMPERATURE RESISTANT, INTEGRAL FUEL TANKS AND FUEL CELL CAVITIES, HIGH ADHESION
Class and Dash Number
AMS-S-8802
PURCHASE ORDER NUMBER ______________________________
MANUFACTURER'S NAME ______________________________
MANUFACTURER'S PRODUCT DESIGNATION ______________________________
BATCH NUMBER ______________________________
DATE OF PACKAGING ______________________________
SHELF LIFE EXPIRATION DATE ______________________________
NET WEIGHT ______________________________
STORE BELOW 80 °F (27 °C)

6. ACKNOWLEDGMENT:

A supplier shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Sealing compound not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Qualification of Sealing Compound:

8.1.1 Awards will be made only for sealing compounds which are, prior to the award of contract, qualified for inclusion in the applicable qualified products list (QPL) whether or not such products have actually been so listed by that date. The attention of contractors is called to these requirements, and manufacturers are urged to arrange to have the sealing compound that they propose to offer tested for qualification in order that they may be eligible to be awarded contracts or orders for the sealing compound covered by this specification. The activity responsible for the QPL is the Performance Review Institute, 161 Thornhill Road, Warrendale, PA 15086-7527, phone (724) 772-1616, fax (724) 772-1699. Information pertaining to qualification of sealing compound may be obtained from that activity.

8.1.2 Qualification shall be approved every three years in accordance with PD 2000 and the instructions from the Performance Review Institute.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

8.3 Procurement documents should specify not less than the following:

Title, number, and date of this specification
Type and size of containers (kits) desired
Quantity of containers (kits) desired
Special packaging, if required.

8.4 Sealing compounds meeting the requirements of this specification have been classified under Federal Supply Classification (FSC) 8030.

8.5 For information purposes, Desoto Coating 823-707 in accordance with MIL-C-27725 Type II Class B has been found to be satisfactory in these tests.

8.6 Key Words:

Sealant, polysulfide, integral fuel tanks, fuel cell, high adhesion

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "G-9"

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3276C

Issued OCT 1993
Revised JAN 1999

Superseding AMS 3276B

Submitted for recognition as an American National Standard

Sealing Compound, Integral Fuel Tanks and General Purpose, Intermittent Use To 360 °F (182 °C)

1. SCOPE:

1.1 Form:

This specification covers five classes of a fuel-resistant polysulfide (T) sealing compound supplied as a two-component system.

1.2 Application:

This sealing compound has been used typically for fuel tank sealing, cabin pressure sealing, and aerodynamic smoothing, but usage is not limited to such applications. It can be used for faying surface sealing, wet-installation of fasteners, overcoating fasteners, sealing joints and seams, and nonstructural adhesive bonding. This room-temperature curing sealing compound can be used in fuel areas as well as nonfuel areas. Curing of this material can be accelerated at higher temperatures. Prior to applying this fuel tank sealant, the bond surfaces should be treated with AMS 3100 adhesion promoter to enhance sealant adhesion. This material is usable from -65 to 250 °F (-54 to 121 °C), with short-term exposure (approximately six hours) to 360 °F (182 °C).

1.3 Classification:

Sealing compounds covered by this specification are classified by method of application and application time (or worklife) as follows:

Class A - Suitable for brush application. Available with the following application times:

a. A-1/2
b. A-2
c. A-4

Class B - Suitable for application by extrusion gun, spatula, brush, or roller; and used, primarily, for fillet sealing, injection sealing, prepack sealing, and rework of damaged fillet seals. Class B sealants are available with the following application times:

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7154 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

1.3 (Continued):

a. B-1/4
b. B-1/2
c. B-1
d. B-2
e. B-4
f. B-6
g. B-12

Class C - Suitable for application by extrusion gun, spatula, brush or roller; and mostly used for fay surface sealing and wet installation of fasteners. Class C materials are available with the following application times; unless otherwise indicated, squeeze-out (or assembly) times are shown in parentheses next to each application time:

a. C-1/2 [not applicable (N/A)]
b. C-2 (N/A)
c. C-8 (20)

Class D - Suitable for application by extrusion gun or spatula. Used for hole and void filling, or for other applications where a very thick sealant is required. Available with the following application times:

a. D-1/4
b. D-1/2

Class E - Suitable for application by automatic riveting equipment. Available as Class E-6.

1.3.1 The specific sealing compound supplied shall conform to the class and application time or squeeze-out time (assembly time) that is ordered.

1.4 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may require the use of hazardous materials, this specification does not address hazards which may be involved in such use. It is the sole responsibility of the user to be familiar with safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2471	Anodic Treatment of Aluminum Alloys, Sulfuric Acid Process, Undyed Coating
AMS 2629	Jet Reference Fluid
AMS 3020	Oil, Reference, for "L" Stock Rubber Testing
AMS 3021	Fluid, Reference, for Testing Di-Ester (Polyol) Resistant Material
AMS 3100	Adhesion Promoter, for Polysulfide Sealing Compounds
AMS 3819	Cloths, Cleaning, for Aircraft Primary and Secondary Structural Surfaces
AMS 4037	Aluminum Alloy Sheet and Plate, 4.4Cu - 1.5Mg - 0.6OMn, (2024; -T3 Flat Sheet, -T351 Plate), Solution Heat Treated
AMS 4045	Aluminum Alloy Sheet and Plate, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr, (7075; T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS 4049	Aluminum Alloy Sheet and Plate, Alclad, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr, (Alclad 7075; -T6 Sheet, -T651 Plate), Solution and Precipitation Heat Treated
AMS 4901	Titanium Sheet, Strip, and Plate, Commercially Pure Annealed, 70.0 ksi (485 MPa) Yield Strength
AMS 5516	Steel Sheet, Strip, and Plate, Corrosion Resistant, 18Cr - 9.ONi (SAE 30302), Solution Heat Treated
AMS-QQ-A-250/4	Aluminum Alloy 2024, Plate and Sheet

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 412	Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension
ASTM D 792	Specific Gravity (Relative Density) and Density of Plastics by Displacement
ASTM D 2240	Rubber Property - Durometer Hardness
ASTM E 1742	Radiographic Examination

2.3 U.S. Government PublicationsU.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

L-P-390	Plastic, Molding and Extrusion Material, Polyethylene and Copolymers (Low, Medium and High Density)
TT-N-97	Naphtha, Aromatic
CCC-C-419	Cloth, Duck, Unbleached, Plied Yarns, Army and Numbered
PPP-B-636	Box, Shipping Fiberboard
PPP-C-96	Can, Metal, 28 Gauge and Lighter
PPP-D-729	Drum, Shipping and Storage, Steel, 55 Gallon (208 Liters)
PPP-P-704	Pails, Metal (Shipping, Steel, 1 through 12 Gallons)
FED-STD-141	Paint, Varnish, Lacquer and Related Materials Method of Inspection, Sampling and Testing
A-A-58054	Abrasive Mats, Non-woven, Non-metallic

2.3 (Continued):

MIL-PRF-23377	Primer Coating, Epoxy, Chemical and Solvent Resistant
MIL-PRF-27725	Coating, Corrosion Preventive, for Aircraft Integral Fuel Tanks
MIL-C-38334	Corrosion Removing Compound, Prepaint, for Aircraft Aluminum Surfaces
MIL-S-38714	Sealant Cartridge for Two Component Materials - Inactive for new design
MIL-C-38736	Compound, Solvent, for Use in Integral Fuel Tanks
MIL-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-PRF-85285	Coating, Urethane, Aliphatic Isocyanate, for Aerospace Applications
MIL-PRF-85582	Primer Coatings, Epoxy Waterborne
MIL-C-87937	Cleaning Compound, Aerospace Equipment
MS-21042	Nut, Self-Locking, 450 oF, Reduced Hexagon, Reduced Height, Ring Base, Non-Corrosion Resistant Steel (ASG)
AN 4	Bolt and Machine, Aircraft

2.4 AIA Publications:

Available from National Standards Association, Inc., 1321 14th Street, NW, Washington, DC 20005.

NAS 679	Nut, Self-Locking, Hexagon Head, Titanium, 190 to 500
NAS1154	Screw,Machine-Flat,10-Degree Head, Close Tolerance, Short Thread, Torque Set

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

The basic ingredient shall be a polysulfide-based synthetic rubber (Thiokol-type, or T-type). The sealing compound shall cure by addition of a curing agent to the base compound; the curing agent is also called a catalyst or accelerator. Curing of the sealing compound shall not depend on solvent evaporation for curing. The material shall contain no lead compounds. The curing agent shall possess sufficient color contrast to base compounds to permit easy identification of an unmixed or incompletely mixed sealing compound. Neither the base compound nor the cured sealant shall be red or pink in color.

3.2 Properties:

The sealing compound, when mixed in accordance with the manufacturers instructions and cured as specified in 4.5.2.8, shall conform to requirements shown in Table 1, determined in accordance with specified test methods.

TABLE 1 - Properties

	Property	Requirement	Test Method
3.2.1	Specific Gravity, max	1.65	4.5.4
3.2.2	Hardness, Shore A Durometer Scale, Instantaneous, min	40	4.5.5
3.2.3	Nonvolatile Content, (% by weight), min		4.5.6
	Class A	85	
	Class B	96	
	Class C	92	
	Class D	97	
	Class E	85	
3.2.4	Viscosity of Base Compound		4.5.7
	Class A	100 to 600 poises (10 to 60 Pa·s)	
	Class B	9,000 to 16,000 poises (900 to 1,600 Pa·s)	
	Class C	1,000 to 4,000 poises (100 to 400 Pa·s)	
	Class D	20,000 to 30,000 poises (2,000 to 3,000 Pa·s)	
	Class E	300 to 800 poises (30 to 80 Pa·s)	
3.2.5	Viscosity of Curing Agent	700 to 2500 poises (70 to 250 Pa·s)	4.5.8
3.2.6	Flow		4.5.9
	Class B	0.10 to 0.75 inch 2.5 to 19.0 mm)	
	Class C	0.010 inch (0.25 mm), min	
	Class D	0.20 inch (5.1 mm), max	

TABLE 1 - Properties (Continued)

	Property	Requirement	Test Method
3.2.7	Application Time, min		
3.2.7.1	Class A - From beginning of mixing, the viscosity shall not exceed 2,500 poises (250 Pa·s).		4.5.10.1
	A-1/2	1/2 hour	
	A-2	2 hours	
	A-4	4 hours	
3.2.7.2	Class B - From beginning of mixing, 15 grams per minute (minimum) shall be extruded.		4.5.10.2
	B-1/4	1/4 hour	
	B-1/2	1/2 hour	
	B-1	1 hour	
	B-2	2 hours	
	B-4	4 hours	
	B-6	6 hours	
3.2.7.3	Class C - From beginning of mixing, 30 grams per minute (minimum) shall be extruded.		4.5.10.2
	C-1/2	1/2 hour	
	C-2	2 hours	
	C-8(20)	8 hours	
3.2.7.4	Class D - From beginning of mixing, 15 grams per minute (minimum) shall be extruded.		4.5.10.2
	D-1/4	1/4 hour	
	D-1/2	1/2 hour	
3.2.7.5	Class E - From beginning of mixing, the viscosity shall be between 800 to 1,100 poises (80 to 110 Pa·s).		4.5.10.3
	E-6	6 hours	
3.2.8	Assembly Time (or Squeeze-out Time), min		4.5.11
	Class C-6	6 hours	
	Class C-20	20 hours	

TABLE 1 - Properties (Continued)

	Property	Requirement	Test Method
3.2.9	Tack-Free Time (Measured from beginning of mixing, max		4.5.12
	Classes B-1/4, D-1/4	6 hours	
	Classes A-1/2, B-1/2, C-1/2, D-1/2	10 hours	
	Class B-1	12 hours	
	Classes A-2, B-2, C-2	24 hours	
	Classes A-4, B-4	36 hours	
	Classes B-6	48 hours	
	Class E-6	120 hours	
	Class B-12	120 hours	
	Class C-8(20)	96 hours	
3.2.10	Standard Cure Time, max (35 Shore A, minimum)		
	Classes B-1/4, D-1/4	16 hours	
	Classes A-1/2, B-1/2. C-1/2. D-1/2	30 hours	
	Classes B-1	36 hours	
	Classes A-2, B-2, C-2	72 hours	
	Classes A-4, B-4	90 hours	
	Classes B-6, C-6	120 hours	
	Class E-6	240 hours	
	Class B-12	240 hours	
	Class C-20	336 hours	
3.2.11	Fluid immersion Cure Time		4.5.14
	Classes B-1/4, A-1/2, B-1/2 only, min		
	After 48 hours	25 Shore A	
	After 120 hours	35 Shore A	
3.2.12	Peel Strength, min		4.5.15, and 4.5.15.1 to 4.5.15.4
3.2.12.1	All classes, except Class C-2	20 pounds force per inch (3503 N/m), 100% cohesive failure	
3.2.12.2	Repairability	10 pounds force per inch (1,751 N/m), 100% cohesive failure	4.5.15.5
3.2.13	Chalking	Slight chalk is permitted	4.5.16
3.2.14	Shear Strength, min Classes C and E only	200 psi (1 379 kPa) average with 100% cohesive failure	4.5.17

TABLE 1 - Properties (Continued)

	Property	Requirement	Test Method
3.2.15	Air Content, max (Class B only)	4%	4.5.18
3.2.16	Weight Loss, Flexibility and Swell		4.5.19
3.2.16.1	Weight Loss, max	8%	
3.2.16.2	Flexibility	No cracking or surface checking	
3.2.16.3	Swell	5 to 15%	
3.2.17	Resistance to Thermal Rupture	No blistering or sponging, 5/32 inch (0.8 mm) deformation, max	4.5.20
3.2.18	Resistance to Thermal Expansion	Sealant flush with groove within +0.010 and -0.003 inch (+0.25 and -0.08 mm) at the wide end of the test block and within +0.005 and -0.003 inch (+0.13 and -0.08 mm) at the narrow end.	4.5.21
3.2.19	Heat Reversion Resistance (Classes B, C, and E only)	The sealant shall not revert to a liquid or paste-like consistency, nor shall it become brittle or lose adhesion.	
3.2.20	Tensile Strength and Elongation Classes B, C-1/2, C-2, C-6, D-1/4, and D-1/2		4.5.23
3.2.20.1	Standard Cure in accordance with 4.5.2.8	250 psi (1724 kPa) 250% elongation	
3.2.20.2	12 days at 140 °F (60 °C) plus 60 hours at 160 ° F (71 °C) plus 6 hours at 180 °F (82 °C), all with the specimens soaking in AMS 2629, Type 1 jet reference fluid (JRF).	125 psi (862 kPa) 100% elongation	
3.2.20.3	12 days at 140 °F (60 °C) plus 60 hours at 160 °F (71 °C) plus 6 hours at 180 °F (82 °C) All with soaking in JRF plus 24 hours at 120 °F (49 °C) plus Standard Heat Cycle in accordance with 4.5.1.3.	125 psi (862 kPa) 25 % elongation	

TABLE 1 - Properties (Continued)

	Property	Requirement	Test Method
3.2.20.4	Standard Heat Cycle in accordance with 4.5.1.3	100 psi (689 kPa) 25% elongation	
3.2.20.5	72 hours in AMS 3020	125 psi (862 kPa) 100 % elongation	
3.2.20.6	72 hours in AMS 3021	125 psi (862 kPa) 100% elongation	
3.2.21	Low-Temperature Flexibility	No visual evidence of cracking, surface checking, or loss of adhesion.	4.5.24
3.2.22	Hydrolytic Stability, min	30 Shore A	4.5.25
3.2.23	Corrosion Resistance	No corrosion or signs of deterioration	4.5.26
3.2.24	Repairability, min	5 pounds force per inch (876 N/m), 100% cohesive failure	4.5.27
3.2.25	Paintability	No separation from sealant	4.5.28
3.2.26	Weather Resistance	No cracking, chalking, peeling, or loss of adhesion	4.5.29
3.2.27	Shaving and Sanding (Class B only)	No rolling or tearing of the sealant	4.5.30
3.2.28	Radiographic Density		4.5.31
3.2.28.1	Difference between bare plate and plate plus selant, max	1.00	
3.2.28.2	Through sealant in the slot, approximately	3.00	
3.2.29	Storage Stability		
3.2.29.1	Accelerated Storage		4.5.32
	Viscosity of Base Compound	Same as 3.2.4	4.5.7
	Viscosity of Curing Agent	Same as 3.2.5	4.5.8
	Flow	Same as 3.2.5	4.5.9
	Application Time	Same as 3.2.6	4.5.10
	Assembly Time	Same as 3.2.7	4.5.11
	Tack-Free Time	Same as 3.2.8	4.5.12
	Peel Strength	Same as 3.2.12	4.5.15

TABLE 1 - Properties (Continued)

	Property	Requirement	Test Method
3.2.29.2	Long-Term Storage		4.5.32
3.2.29.2.1	Application Time; hours, max		
	Classes B-1/4, D-1/4	0.25	
	Classes A-1/2, B-1/2, C-1/2, D-1/2	0.5	
	Class B-1	1	
	Classes A-2, B-2, C-2	2	
	Classes A-4, B-4	4	
	Classes B-6, C-6	6	
	Class E-6	6	
	Class B-12	12	
	Class C-20	20	
3.2.29.2.2	Tack-Free Time, hours, max		
	Classes B-1/4, D-1/4	16	
	Classes A-1/2, B-1/2, C-1/2 D-1/2	20	
	Class B-1	24	
	Classes A-2, B-2, C-2	48	
	Classes A-4, B-4	72	
	Classes B-6, C-6	96	
	Classes E-6, B- 1 2	180	
	Class C-20	144	
3.2.29.2.3	Cure Time, hours, max		
	Classes B-1/4, D-1/4	24	
	Classes A-1/2, B-1/2, C-1/2, D-1/2	40	
	Class B-1	54	
	Classes A-2, B-2, C-2	72	
	Classes A-4, B-4	114	
	Classes B-6, C-6	144	
	Classes E-6, B-12	264	
	Class C-20	360	

3.3 Performance and Application Requirements:

Properties are divided into two classes; performance requirements and application requirements. Performance requirements define those properties of the cured sealant and its performance in service. Application requirements define the properties of uncured sealant; and they affect the application parameters of the sealant but have little or no effect on the performance properties of cured sealant. Minor variations in application requirements during acceptance testing may not be cause for rejection if approved by the procuring agency. Application requirements are listed below; all other requirements are performance requirements.

a. Viscosity of Base Compound
b. Flow
c. Application Time
d. Tack-Free Time
e. Cure Time
f. Fluid Immersion Cure Time

3.4 Quality:

The base compound and curing agent, as received by the purchaser, shall each be of uniform blend and shall be free of excessive air, skins, lumps, and gelled or coarse particles. There shall be no separation of ingredients which cannot be easily redispersed.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of the sealing compound shall supply all samples and shall be responsible for all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the sealing compound conforms to all requirements of this specification.

4.1.1 Shelf-Life Surveillance and Updating:

4.1.1.1 Sampling: The minimum number of samples to be tested during shelf-life surveillance and updating is shown in Table 2.

TABLE 2 - Shelf-life Surveillance Samples

Items in Stock	Samples to be Tested
Up to 100, excl	3
100 to 500, incl	5
Over 500	7

4.1.1.2 Testing The following inspections are to be conducted for shelf-life surveillance and updating:

a. Condition of Container
b. Application Time
c. Tack-free Time
d. Standard Cure Time
e. Viscosity of Base Compound (not possible with sectional-type containers)
f. Peel Strength - Two aluminum panels coated with MIL-PRF-27725, corrosion-preventive coating, soaked in JRF for seven days at 140 °F (60 °C).

4.1.1.2.1 Tests are to be conducted at the end of the stated shelf-life, in accordance with test methods outlined in this specification for acceptance tests. If tests are being performed to update the shelf-life of the sealing compound, and all tests are passed, the shelf-life will be extended an additional three months. Up to three updatings will be allowed.

4.1.2 Curing Compound Replacement: There are instances where sealant will become overaged and require excessive time to cure. Usually, the curing agent will be the component that has deteriorated; but curing agent can be replaced, so that the sealant can be used. Any time the curing agent is replaced, all the acceptance tests must be met by the final combination of curing agent plus base compound.

4.2 Classification of Tests:

4.2.1 Qualification Tests: All technical requirements are qualification tests (See 8.2) and shall be performed prior to or on the initial shipment of sealing compound to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.1.1 Class B-2 shall be the first material that is qualified for each supplier of sealing compound (See 8.2). Class B-2 sealing compound shall meet all technical requirements of this specification with the exception of requirements applicable to other classes.

4.2.1.2 Once qualification for Class B-2 is obtained, other classes may be qualified. The formulation for other classes, and for other Class B materials, shall be the same as Class B-2, except for minor variations necessary for conformance to viscosity and application time requirements.

4.2.1.3 The manufacturer shall present written proof to the purchaser that all requirements are met prior to requesting qualification approval for any class. This includes assurance that the sealant will cure at standard conditions. Acceptance testing is conducted on sealant cured at 140 °F (60 °C). After the sealing compound has been accepted for qualification, approval will be granted and the sealant will be identified by reference to the manufacturer's code or formula number.

4.2.2 Acceptance Tests: The following requirements are acceptance tests and shall be performed on each batch. A batch shall be the quantity of sealing compound run through a mill or mixer at one time.

a. Hardness (3.2.2)
b. Nonvolatile Content (3.2.3)
c. Viscosity of Base Compound (3.2.4) (See 4.2.2.1)
d. Flow (3.2.5)
e. Application Time (3.2.6)
f. Assembly Time (C-6 and C-20 only) (See 3.2.7)
g. Tack-Free Time (See 3.2.8)
h. Standard Cure Time (all classes except Class C-20) (See 3.2.9)
i. Fluid Immersion Cure Time (Classes B-1/4, A-1/2, B-1/2) (See 3.2.10)
j. Peel Strength (All classes except Class C-20) (See 3.2.11)
k. Chalking (See 3.2.12)
l. Shear Strength (Classes C and E only) (See 3.2.13)
m. Air Content (Class B only) (See 3.2.14)
n. Weight Loss, Flexibility and Swell (See 3.2.15)
o. Resistance to Thermal Rupture (See 3.2.16)

4.2.2.1 Testing need not be performed on sealant packaged in sectionalized containers or small size containers of under 8 ounces (237 ml).

4.2.2.2 Acceptance test requirements can be satisfied by use of the National Aerospace Defense Contractor's Accreditation Program (NADCAP) or by performing the tests required by 4.2.2. If the NADCAP system is used, the sealant manufacturer must be NADCAP accredited and product surveillance in accordance with NADCAP procedures must be performed on each batch of sealant. All tests specified in 4.2.2 must be performed by the manufacturer.

4.3 Sampling and Testing:

4.3.1 Sampling and testing for qualification tests shall be as follows:

Samples shall consist of one 5-gallon (19-L) and two 1-quart (0.95-L) containers of sealing compound. Samples shall be identified as follows and forwarded to the activity responsible for qualification testing as designated in the letter of authorization from the activity (See 8.2).

SEALING COMPOUND, INTEGRAL FUEL TANK AND GENERAL PURPOSE, INTERMITTENT USE TO 360 °F (182 °C)
SPECIFICATION AMS 3276C
MANUFACTURER'S IDENTIFICATION
NAME OF MANUFACTURER
LOT NUMBER
DATE OF MANUFACTURE
SUBMITTED BY (NAME) (DATE) FOR QUALIFICATION TESTS IN ACCORDANCE WITH AMS 3276C UNDER AUTHORIZATION (REFERENCE AUTHORIZING LETTER)

4.3.2 For Acceptance Tests: Sufficient sealing compound shall be taken at random from each batch to perform all required tests. The number of determinations for each requirement shall be as specified in the applicable test procedure; or, if not specified, at least three determinations shall be made for each requirement. Multiple testing is not required for viscosity, application time, flow, tack-free time, and hardness.

4.3.2.1 Sealing compound for testing shall be mixed, whenever possible, in the same containers in which materials were procured.:

4.3.2.2 If the sealing compound is being procured in sectional plastic injection kits, all tests shall be conducted on compound that has been packaged and mixed in the initial sample injection kits except for viscosity of the base compound. During filling of the initial sample injection kits, base compound and curing agent shall be placed in 1-quart (0.95-L) cans for the viscosity of base test (see 4.5.7). If more than one size of injection kit will be packaged from a particular batch, select one size for testing the sealing compound.

4.3.2.3 If sealing compound is being procured in cans, pails, or drums, the batch shall be tested on material placed in 1-quart (0.95-L) cans.

4.3.2.4 If sealing compound is being procured in all of the above types of containers, quality conformance tests shall be conducted on sealing compound packaged in plastic injection kits (See 4.3.2.2).

4.3.2.5 A statistical sampling plan, which is acceptable to the purchaser, may be used as an option to sampling in accordance with 4.3.2.

4.3.2.6 U.S. Government Procurement Each batch shall be subjected to both initial and final acceptance testing. Sufficient compound for initial acceptance testing shall be packaged in the same type containers that are being procured. Initial acceptance tests are listed in 4.2.2. Final acceptance testing is to be conducted on the final packaged product and consists of application time, tack-free time, standard cure time, and air content. After successful completion of initial quality conformance tests, the batch shall be released for final packaging. During packaging, test kits shall be picked at random to perform the following final acceptance tests

a. Application Time (3.2.6)
b. Tack-free Time (3.2.8)
c. Standard Cure Time (3.2.9)
d. Air Content (3.2.14).

4.3.2.6.1 If the batch is packaged in different types (or sizes) of containers, final acceptance tests shall be conducted on each type (or size) of container. If sealing compound is being procured under different purchase orders, but the purchase orders call for the same type and size of containers, final acceptance tests shall be performed only once.

4.4 Approval:

4.4.1 Sealing compound shall be approved by the purchaser before being supplied for production use, unless such approval is waived by purchaser. For direct procurement, sealing compound shall be listed (or approved for listing) on the current qualified products list (QPL) for this specification. Results of tests on production sealing compound shall be essentially the same as those on the qualification sample.

4.4.2 The sealant manufacturer shall use ingredients, manufacturing procedures, processes, and methods of inspection on production sealing compound which are essentially the same as those used on the approved sample. If necessary to make any change in ingredients, in the type of equipment for processing, or in manufacturing procedures, the sealant manufacturer shall submit for reapproval a statement of proposed changes in ingredients and/or processing. If requested by the purchaser, the sealant manufacturer shall submit a sample of sealing compound. Production sealing compound made by a revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Test Methods:

Methods (or procedures) for testing of materials to the Engineering requirements of this specification shall be as follows:

4.5.1 Standard Conditions:

4.5.1.1 Test Conditions: Standard laboratory test conditions shall be 77 °F ± 2 °F (25 °C ± 1 °C) and 50% ± 5% relative humidity. Unless otherwise specified herein, all test specimens shall be prepared and cured, and all tests shall be performed, under these conditions.

4.5.1.2 Standard Tolerances: Unless otherwise specified herein, standard tolerances shown in Table 3 shall apply.

TABLE 3 - Standard Tolerances

Measurement Units	Tolerances
Temperatures	±2 °F (1 °C)
Days	±2 hours
Hours	±5 minutes
Minutes	±10 seconds
Inches (mm)	±0.01 inch (0.25 mm)

4.5.1.3 Standard Heat Cycle: Standard heat cycle shall consist of the cure cycle of 4.5.2.8 followed by 24 hours ± 1 hour at 260 °F (127 °C), 4 hours ± 0.5 hour at 320 °F (160 °C), 6 hours ± 1 hour at 360 °F (182 °C) divided evenly into six portions, each consisting of 4 hours ± 0.5 hour at 260 °F (127 °C), 40 minutes ± 5 minutes at 32 °F (160 °C), and 1 hour ± 5 minutes at 360 °F (182 °C). At the completion of each 360 °F (182 °C) exposure, temperatures shall be reduced to below 100 °F (38 °C) before repeating exposure to the 260 °F (127 °C) cycle.

4.5.2 Preparation of Test Specimens:

4.5.2.1 Chemical Conversion Coating Application:

4.5.2.1.1 Coating Preparation: A chemical conversion coating, conforming to MIL-C-81706, Class 1A, Form II, Method C, shall be prepared according to the coating manufacturer's instructions. Nitric acid shall be used to adjust the coating solution's pH to 1.5.

4.5.2.1.2 Panel Preparation: Vapor or solvent degrease and alkaline detergent clean using MIL-C-87937, Type II or Type IV cleaning compound. Cleaning may be accomplished by brushing, swabbing, or soaking the panels in the detergent solution or by a combination of the above techniques. Rinse the cleaned panels in warm flowing tap water, 60 to 100 °F (16 to 38 °C), and check for cleanliness by observing for a waterbreak-free surface. If waterbreak occurs on the panel surfaces, return the panels to the detergent solution; and repeat the cleaning procedure until a waterbreak-free surface is obtained. Immediately transfer the cleaned panels to a deoxidizing solution consisting of the following:

a. Butyl alcohol 35% by weight
b. Distilled or deionized water 22% by weight
c. Isopropyl alcohol 25% by weight
d. Phosphoric acid (85% by weight) 18% by weight.

4.5.2.1.2.1 Acid deoxidizer conforming to MIL-C-38334 may also be used. Allow the panels to remain in solution of 4.5.2.1.2 for 3 to 5 minutes. Rinse the panels thoroughly under flowing tap water.

4.5.2.1.3 Coating Application (immersion): Transfer the deoxidized panels immediately to the MIL-C-81706 chemical conversion coating solution. Immerse the panels in the solution at standard temperature (See 4.5.1.1) for 3 to 5 minutes or until a light straw color develops. Color development time will vary with the aluminum alloy being conversion coated. After removal from the conversion coating solution, immediately rinse thoroughly in flowing distilled or deionized water. Arrange the panels in an upright position to drain dry; and protect panels against contamination. Apply the test materials to the conversion coated surfaces within 48 hours.

4.5.2.1.3.1 Mix the conversion coating solution either in 18-8 type stainless steel, polyethylene, or other compatible plastic containers. Do not mix the conversion coating solution in glass containers.

4.5.2.2 Cure of Composite Panels: AS 4/3501-6 shall be fabricated using eight plies of unidirectional tape laid (0, 45, 90, 135) symmetrical. Size of the test panels shall be 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm). Cure in accordance with 4.5.2.2.1.

4.5.2.2.1 Install peel ply to bag surface of laminate. Nylon peel ply is acceptable. Apply a vacuum of not less than 28 inches (711 mm) of mercury and 85 psi (586 kPa) pressure.

Heat to 225 °F (107 °C) at 1 to 4 F-degrees per minute (1 to 2 C-degrees per minute). Hold at 225 °F (107 °C) for one hour. Heat to 350 °F (177 °C) at 1 to 4 F-degrees per minute (1 to 2 C-degrees per minute). Hold at 350 °F ± 10 (177 °C ± 6) for two hours. Cool to 150 °F (66 °C) while maintaining vacuum and pressure. Remove the peel ply.

4.5.2.3 Preparation of Sealing Compound:

4.5.2.3.1 For Qualification Tests: The quantity of sealing compound required for the tests shall be mixed as thoroughly as practical. Classes B-2, B-4, B-6, and B-12 shall be machine mixed. Classes B-1/4, B-1/2, and all dash numbers for Classes A, C, D, and E shall be hand-mixed. The sealing compound shall have a minimum inclusion of air. Where applicable, the sealing compound, immediately after mixing, shall be placed in cartridges for extrusion from a pneumatic sealing gun. Sealing compound in sectional-type containers (such as Semkits) shall be machine mixed.

4.5.2.3.2 Acceptance Tests: The quantity of sealing compound required for tests shall be hand-mixed or machine mixed in accordance with instructions from the manufacturer of the sealing compound. MIL-S-38714 containers shall be used when applicable.

4.5.2.4 Quick Freezing: After machine mixing, two cartridges shall be held at room temperature. One cartridge shall be used for testing application time and the other for tack-free time, curing rate, and flow. The remainder of the cartridges shall be quick frozen. After the compound is loaded into the cartridges, both ends of the cartridges shall be closed after filling. The installed plunger constitutes a satisfactory plug at one end. The sealant shall be quick frozen immediately in TT-N-97, Type 1, Grade B, aromatic naphtha and dry ice bath at -80 °F (-62 °C) or lower for 30 minutes. The cartridge shall be placed in a plastic bag and immersed with its plugged nozzle end down and the upper end about 1 inch (25 mm) above the liquid level. Storage time of quick-frozen material shall not exceed 10 days at -67 °F (-55 °C). Thaw-out shall be accomplished by immersion of frozen cartridges in a 120 °F (49 °C) water bath for 18 minutes with the plugs installed and the upper end of the cartridge shall be 1 inch (25 mm) above the liquid level. Time zero is when the 18-minute period ends and the timed tests are started. Sealant may be thawed out by standing at room temperature, instead of by immersion in hot water.

4.5.2.5 Cleaning of Test Panels: All test panels shall be cleaned by scrubbing and rinsing with MIL-C-38736, Type I or Type II solvent and clean AMS 3819, Grade A cloths which are free of sizing and any other contaminants. The panels shall be wiped dry immediately with clean AMS 3819, Grade A cloths. Titanium, stainless steel, and carbon-reinforced epoxy (composite) panels shall be scrubbed with abrasive mats and MIL-C-38736, Type I or Type II solvent. After scrubbing, the panels shall be rinsed using MIL-C-38736, Type I or Type II solvent and clean cloth, followed by wiping the panel surfaces until dry. Abrasive mats shall conform to A-A-58054, Type I, Class 1, Grade A, for stainless steel and composite panels and A-A-58054, Type III, Class 1, Grade A, for titanium panels.

4.5.2.5.1 When organic coatings are specified for test panels, the coatings shall be fully cured before cleaning; cure of organic finishes shall be in accordance with the applicable coating specification,. Applied coatings shall be at least 14 days old and not more than six months old when stored at ambient indoor temperatures.

4.5.2.6 Application of Adhesion Promoter: When specified, the panel surface shall be treated with AMS 3100 adhesion promoter, immediately after the panel is cleaned, by wetting a clean AMS 3819, Grade A cloth and wiping the surface. Allow adhesion promoter to air-dry for 30 minutes to two hours before applying sealant. If more than two hours has elapsed, reclean and reapply the adhesion promoter before applying sealant.

4.5.2.7 Application of Sealing Compound: Unless otherwise specified herein, test panels shall be given an application of sealing compound to produce a coating having a total thickness of 0.125 inch ± 0.016 inch (3.18 mm ± 0.41 mm) when cured. For Class A material, a time equal to the rated application life shall be used between applications to permit release of solvents.

4.5.2.8 Cure of Sealing Compound: For qualification testing, the sealing compound shall be cured for 14 days at 77 °F (25 °C) and 50% ± 5% relative humidity. For acceptance testing, the sealing compound shall be given an accelerated cure for 48 hours at 77 °F (25 °C) and 50% ± 5% relative humidity plus 24 hours at 140 °F (60 °C). Tests on cured sealing compound shall begin within two days of when the specified cure is completed.

4.5.3 Jet Reference: The jet reference fluid (JRF) required for fluid immersion tests shall conform to AMS 2629. Type 1 fluid shall be used for all tests that require exposure of specimens to JRF, except Type 2 JRF shall be used for the chalking test (4.5.15).

4.5.4 Specific Gravity: Three test specimens, approximately 0.125 x 1 x 1 inch (3.18 x 25 x 25 mm), shall be cut out with a sharp razor blade or scalpel from a sheet of sealing compound that has been cured as in 4.5.2.8. Determine the specific gravity of each sample in accordance with ASTM D 792, Method A, and report the average value.

4.5.5 Hardness: The instantaneous hardness shall be determined in accordance with ASTM D 2240, Method 3021, after the sealing compound is cured as in 4.5.2.8. The reading shall be taken on a double back-to-back, 0.125 inch (3.18 mm)-thick specimen making the total thickness 0.25 inch (6.4 mm).

4.5.6 Nonvolatile Content: Within five minutes after mixing or warming to application temperature, 1 to 12 grams of mixed sealing compound shall be transferred, as rapidly as possible, to a previously weighed (W1) aluminum dish approximately 2 inches (51 mm) in diameter. The Class A and Class C sealants shall be poured into the dish. Class B sealant shall be extruded from a plastic cartridge, fitted with 0.125 inch (3.18 mm) orifice nozzle, to fill the bottom of the dish to a uniform depth. The initial weight (W2) shall be determined using an analytical balance accurate within ±1 milligram. Immediately after weighing, place the sample and dish in a circulating-air oven preheated to 160 °F (71 °C) for three days; then, remove the sample and dish from the oven and cool them at room temperature in a desiccator. Final weight (W3) of the sample and dish shall be determined on the same balance used for initial weights. All weights shall be recorded to the nearest milligram.

4.5.6.1 Percent nonvolatile content shall be determined from the average of three samples and calculated as shown in Equation 1:

$$\text{Percent Nonvolatile} = \frac{(W3 - W1)}{(W2 - W1)} \times 100 \qquad \text{(Eq. 1)}$$

4.5.7 Viscosity of Base Compound:

4.5.7.1 Shall be determined with the base compound placed in a 1-quart (0.95-L) can. The can shall be filled with the base compound to within 0.5 inch (13 mm) of the top, covered, and stored at 77 °F (25 °C) for not less than eight hours. The base compound shall be thoroughly mixed by stirring slowly for not less than three minutes after which the can shall be closed and the base compound shall be allowed to stand for one hour.

4.5.7.2 The Brookfield Model RVF viscometer, or equivalent, shall be used. Viscometer readings shall be converted to poises (Pa·s). For Class A sealant, the No. 6 spindle, at 10 rpm, shall be used. For Classes B and D sealants, the No. 7 spindle, at 2 rpm, shall be used. For Class C sealant, the No. 6 spindle, at 2 rpm, shall be used. For Class E sealant, the No. 7 spindle, at 10 rpm, shall be used. The highest reading shall be taken after the instrument has run in the base compound for at least one minute.

4.5.8 Viscosity of the Curing Agent: The viscosity of the curing agent shall be determined in accordance with 4.5.7, except a No. 7 spindle at 10 rpm shall be used.

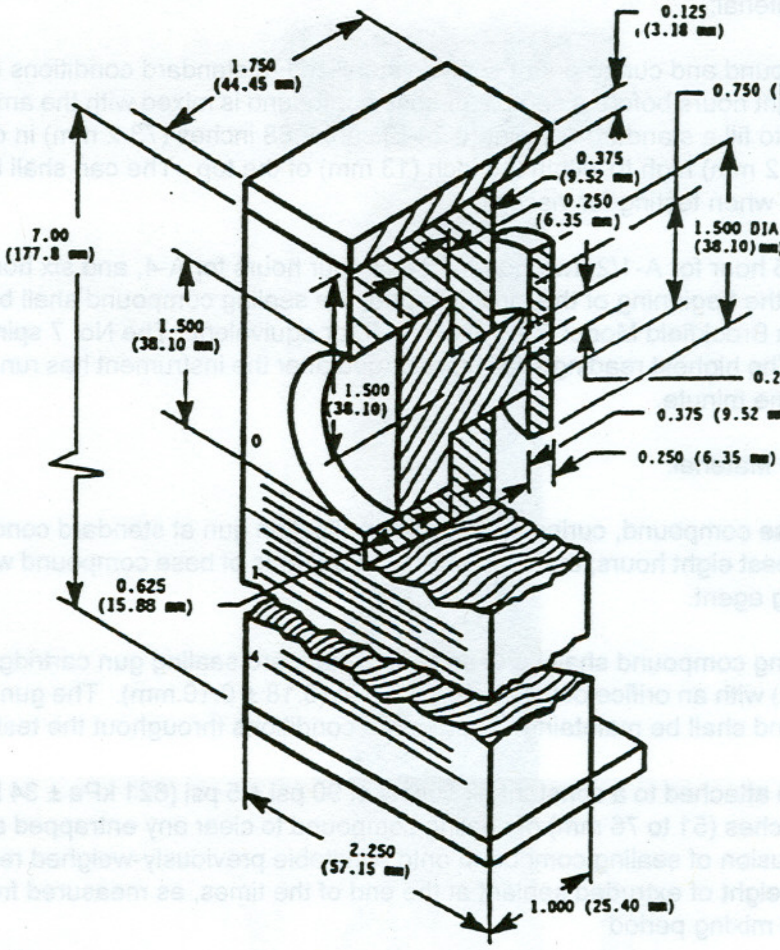
4.5.9 Flow (Classes B, C and D Only):

4.5.9.1 Classes B and D: A standard sealant gun cartridge, fitted with a suitable nozzle, shall be filled with freshly mixed sealing compound. The gun and sealing compound shall be maintained at standard conditions (4.5.1.1) throughout the test. The test shall be conducted with a flow test fixture as shown in Figure 1. Depth of the plunger tolerance is critical and shall be controlled within the specified tolerance during all tests. The flow fixture shall be placed on a table with the front face upward and the plunger depressed to the limit of its travel. Within 15 minutes after the beginning of mixing, enough mixed sealing compound shall be extruded from the application gun to fill the recessed cavity of the fixture. Then, the mixed sealing compound shall be leveled off with the block. The test at this interval shall be considered the initial flow of the sealing compound. Within ten seconds after the leveling operation, the fixture shall be placed on its end and the plunger immediately advanced to the limit of its forward travel.

The flow measurement shall be taken exactly 30 minutes after the sealing compound has been applied to the test fixture. The flow shall be measured from tangent to the lower edge of the plunger to the farther point to which the flow has advanced. The flow test shall be repeated at the time intervals specified below. All time intervals, other than for the initial test, shall be measured from the end of the mixing period.

a. B-1/4, D-1/4 Initial Reading Only
b. B-1/2, D-1/2 Initial Reading Only
c. B-1 Initial, 30 minutes
d. B-2 Initial, 50 minutes, 90 minutes
e. B-4 Initial, 2 hours, 3.5 hours
f. B-6 Initial, 3 hours, 5.5 hours
g. B-12 Initial, 6 hours, 11.5 hours.

4.5.9.2 Class C: A 0.015 to 0.020 inch (0.38 to 0.51 mm) layer of freshly mixed sealant shall be applied to an AMS 4049 aluminum alloy panel; dimensions of this panel shall be 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm). Immediately place the panel in a vertical position; and keep it in that position for a period equivalent to the rated tack-free time. The sealant thickness at its thinnest spot shall conform to 3.2.6.



NOTES:

Material: Aluminum alloy

Dimensions in inches (millimeters)

Tolerances: Decimals +/- 0.016 inch (+/- 0.41 mm) **(NOT TO SCALE)**

FIGURE 1 - Flow-Test Fixture

4.5.10 Application Time:

4.5.10.1 Class A and E Material:

4.5.10.1.1 The base compound and curing agent shall be stabilized at standard conditions (4.5.1.1) for not less than eight hours before a sample of base compound is mixed with the amount of curing agent sufficient to fill a standard 0.5-pint (0.24-L) can, 2.88 inches (73.2 mm) in diameter by 2.88 inches (73.2 mm) high to within 0.5 inch (13 mm) of the top. The can shall be tightly covered, except when testing for viscosity.

4.5.10.1.2 At the end of 0.5 hour for A-1/2, two hours for A-2, four hours for A-4, and six hours for E-6, measured from the beginning of the mixing period, the sealing compound shall be tested for viscosity using a Brookfield Model RVF viscometer, or equivalent. The No. 7 spindle at 10 rpm shall be used. The highest reading shall be recorded after the instrument has run in the sealing compound for one minute.

4.5.10.2 Class B, C, and D Material:

4.5.10.2.1 Stabilize the base compound, curing agent, and application gun at standard conditions (4.5.1.1) for at least eight hours; then mix at least 250 grams of base compound with the proper amount of curing agent.

4.5.10.2.2 The mixed sealing compound shall be used to fill a standard sealing gun cartridge, having a nozzle (Figure 2) with an orifice of 0.125 inch ± 0.004 (3.18 ± 0.10 mm). The gun cartridge and sealing compound shall be maintained at standard conditions throughout the test.

4.5.10.2.3 The gun shall be attached to a constant air supply of 90 psi ± 5 psi (621 kPa ± 34 kPa). Initially, extrude 2 to 3 inches (51 to 76 mm) of sealing compound to clear any entrapped air. Perform a one-minute extrusion of sealing compound onto a suitable previously-weighed receptacle; and determine the weight of extruded sealant at the end of the times, as measured from the beginning of the mixing period

4.5.10.2.3.1 0.25 hour for Classes B-1/4 and D-1/4

4.5.10.2.3.2 0.5 hour for Classes B-1/2, C-1/2, and D-1/2

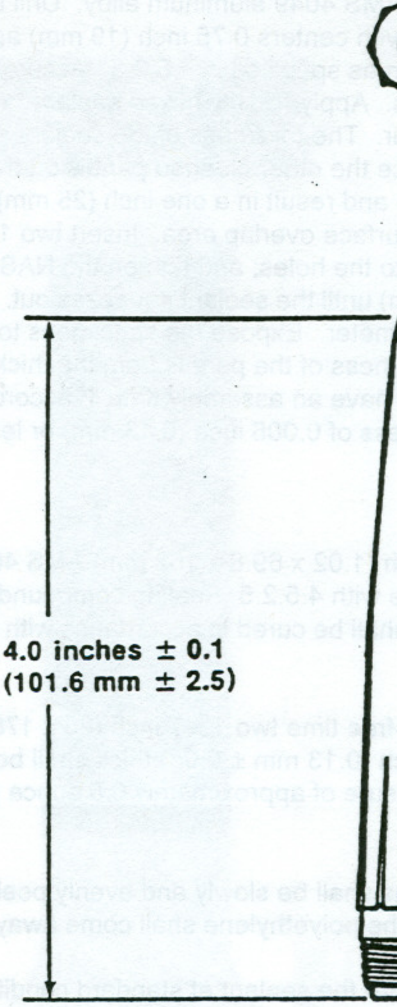
4.5.10.2.3.3 1 hour for Class B-1

4.5.10.2.3.4 2 hours for Classes B-2 and C-2

4.5.10.2.3.5 4 hours for Class B-4

4.5.10.2.3.6 6 hours for Classes B-6 and C-6

4.5.10.2.3.7 12 hours for Classes B-12 and C-20.



NOTES:

1. Orifice diameter shall be 0.125 inch +/- 0.004 (3.18 mm +/- 0.10).
2. Material shall be polyethylene conforming to L-P-390.

FIGURE 2 - Standard Test Nozzle

4.5.11 Assembly Time (Class C Only): Six test panels, 0.040 x 1.5 x 4 inches (1.02 x 38 x 102 mm), shall be prepared from AMS 4049 aluminum alloy. Drill two holes with a No. 1 drill, 1.2 inches (30 mm) from one end with centers 0.75 inch (19 mm) apart and 0.38 inch (9.7 mm) from each side. Deburr; then clean as specified in 4.5.2.5. Accurately determine the thickness of the panels around the holes. Apply freshly mixed sealant to the drilled end of three specimens and allow to cure for 0.5 hour. The thickness of the sealant shall be 0.010 to 0.015 inch (0.25 to 0.38 mm). Place the other cleaned panels on those to which sealant has been applied, so that the holes line up and result in a one inch (25 mm) overlap. Sealant shall cover the entire 1 inch (25 mm) faying surface overlap area. Insert two 10-32 steel bolts, heat treated to at least 160 ksi (1,103 MPa), into the holes; and tighten the NAS 679-A3 nuts to a torque value of 40 inch pounds (4.5 N-m) until the sealant squeezes out. Measure the thickness of the assembly at the bolts with a micrometer. Expose the specimens to standard conditions (4.5.1.1) for four hours. Subtract the thickness of the panels from the thickness of the assembly. The mixed sealing compound shall have an assembly time in accordance with 3.2.7. The sealant must squeeze out to a thickness of 0.005 inch (0.13 mm) or less.

4.5.12 Tack-Free Time:

4.5.12.1 A 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm) AMS 4049 aluminum alloy panel shall be cleaned in accordance with 4.5.2.5. Sealing compound shall be applied in accordance with 4.5.2.7. The sealant shall be cured in accordance with 4.5.2.8 until the end of its tack-free time (See 3.2.9).

4.5.12.2 At the end of the tack-free time two 1 x 7 inch (25 x 178 mm) strips of polyethylene 0.005 inch ± 0.002 inch (0.13 mm ± 0.05) thick shall be applied to the sealing compound and held in place at a pressure of approximately 0.5 ounce per square inch (0.0002 N/mm^2) for two minutes.

4.5.12.3 The polyethylene strips shall be slowly and evenly peeled back at right angles to the sealing compound surface. The polyethylene shall come away clean and free of sealing compound.

4.5.13 Standard Cure Time: Cure the sealant at standard conditions (4.5.1.1) for the time specified in 3.2.10; then, determine the sealant's hardness in accordance with ASTM D 2240 (instantaneous) using a Type A durometer. The hardness reading shall be taken on a double back-to-back, 0.125 inch (3.18 mm) thick specimen.

4.5.14 Fluid Immersion Cure Time (Classes A-1/2, B-1/4, B-1/2 and C-1/2 only): An AMS 4049 aluminum alloy test panel, 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm), shall be cleaned in accordance with 4.5.2.5 and covered with sealing compound to a depth of 0.25 inch (6.4 mm). After curing at standard conditions for six hours. the test panel shall be immersed in AMS 2629, Type 1 JRF at 77 oF (25 °C). The hardness shall be determined, after 48 hours (42 hours in JRF) and after 120 hours (114 hours in JRF), in accordance with ASTM D 2240 (instantaneous) using a Type A Durometer.

4.5.15 Peel Strength (All Classes except C-20):

4.5.15.1 The type, quantity, and thickness of panels shown in Table 4 shall be used for evaluation of peel strength. All panels shall be as described in Figure 3. The panels shall be prepared in accordance with Table 4. The manufacturer's recommended adhesion promoter shall be applied as in 4.5.2.6. The center 4 inches (102 mm) of the panels shall be coated on one face with a 0.125 inch (3.18 mm) thickness of sealing compound. An optional configuration consists of coating the bottom [approximately 5 inches (127 mm)] of the panel with sealant (Figure 3). A 2.75 x 12 inch (69.8 x 305 mm) strip of wire screen [20 to 40 (850 to 425 mm) mesh aluminum or monel wire fabric or CCC-C-419, Type 3, cotton duck cloth shall be impregnated with sealing compound, so that approximately 5 inches (127 mm) at one end is completely covered on both sides. The sealant-coated end of the fabric shall be placed on the sealant-coated panel; then, the sealant-coated end of the fabric shall be compressed onto the layer of sealing compound, taking care not to entrap air. An additional coating of sealing compound -- approximately 0.031 inch (0.79 mm) thick -- shall be applied over the fabric. The sealant shall be given a standard cure as in 4.5.2.8.

TABLE 4 - Peel Strength Panels

Quantity	Panel Material	Panel Thickness
6	AMS 4049 aluminum alloy, chemical treated in accordance with 4.5.2.1	0.040 inch (1.02 mm)
6	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471	0.040 inch (1.02 mm)
6	AMS 5516 stainless steel (Use AMS 3100 adhesion promoter prior to sealing.)	0.025 to 0.040 inch (0.64 to 1.02 mm)
10[1]	AMS 4901 titanium (Use AMS 3100 adhesion promoter prior to sealing)	0.025 to 0.040 inch (0.64 to 1.02 mm)
10[1]	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, and coated with MIL-PRF-27725	0.040 inch (1.02 mm)
6	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, and coated with MIL-PRF-27725 (Use AMS 3100 adhesion promoter prior to sealing)	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, coated with MIL-PRF-23377, and cured seven days at standard conditions	0.040 inch (1.02 mm)

TABLE 4 - Peel Strength Panels (Continued)

Quantity	Panel Material	Panel Thickness
2	AMS 4045 aluminum alloy sulfuric acid anodized in accordance with AMS 2471, coated with MIL-PRF-23377, cured two hours at 200 °F (93 °C)	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, coated with MIL-PRF-23377 and MIL-PRF-85285 urethane topcoat	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, coated with MIL-PRF-23377 and coated with MIL-PRF-85285 urethane topcoat	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy, sulfuric acid anodized in accordance with AMS 2471, coated with MIL-PRF-85582 waterbased primer. (Use AMS 3100 adhesion promoter prior to sealing.)	0.040 inch (1.02 mm)
2	Carbon-reinforced epoxy (composite) as specified in 4.5.2.2. (Test ply side and tool side; do not test both sides of same panel.)	0.040 inch (1.02 mm)

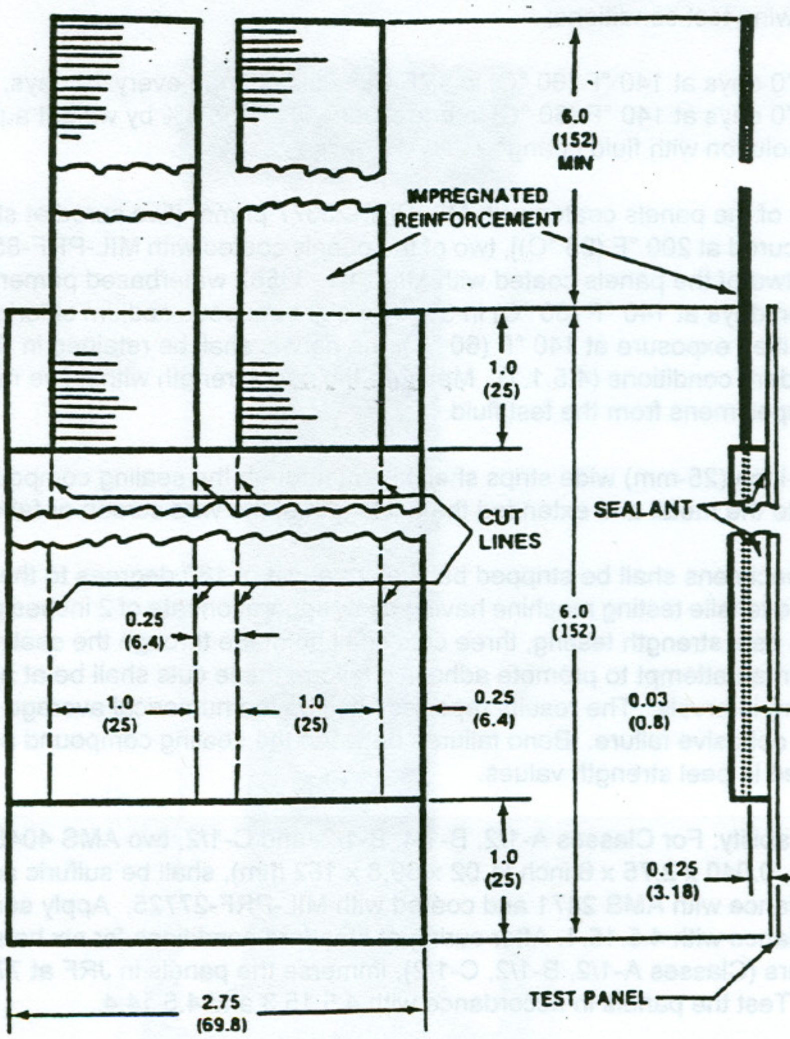
[1]See 4.5.15.2.1.

4.5.15.2 After the sealing compound has been cured, two panels of each substrate listed in Table 4 shall be subjected to each of the following test conditions.

EXCEPTION: Do not expose the specimens that were coated with MIL-PRF-23377 primer, MIL-PRF-85285 topcoat, or MIL-PRF-85582 primer:

a. Seven days at 140 °F (60 °C) in AMS 2629, Type 1 JRF;
b. Seven days at 140 °F (60 °C) in equal parts of JRF and 3% by weight aqueous sodium chloride solution;
c. 100 hours at 140 °F (60 °C), 10 hours at 160 °F (71 °C), 1 hour at 180 °F (82 °C) in equal parts JRF and 3% by weight aqueous sodium chloride solution.

Repeat the above cycle five times (for a total of six cycles), using new fluid each time.



NOTES:

1. Dimensions are in inches (millimeters).
2. Unless otherwise specified, dimensions shown shall be nominal.
3. Sealant and fabric covers lower 1 inch (25 mm) of panel in the optional specimen.

FIGURE 3 - Peel Specimen Configuration

4.5.15.2.1 Two panels of each substrate marked in Table 4 with an asterisk (*) shall be exposed to the following test conditions:

a. 70 days at 140 °F (60 °C) in JRF with fluid change every 14 days.
b. 70 days at 140 °F (60 °C) in equal parts JRF and 3% by weight aqueous sodium chloride solution with fluid change every 14 days.

4.5.15.2.2 Four of the panels coated with MIL-PRF-23377 primer [two cured at standard conditions and two cured at 200 °F (93 °C)], two of the panels coated with MIL-PRF-85285 urethane topcoat, and two of the panels coated with MIL-PRF-85582 waterbased primer shall be subjected to seven days at 140 °F (60 °C) in 3% by weight aqueous sodium chloride solution. After the specified exposure at 140 °F (60 °C), the panels shall be retained in the fluid for one day at standard conditions (4.5.1.1). Measure the peel strength within five minutes after removal of the specimens from the test fluid.

4.5.15.3 Two 1-inch (25-mm) wide strips shall be cut through the sealing compound and wire screen or fabric to the metal and extended the full length of the wire screen or fabric.

4.5.15.4 The specimens shall be stripped back at an angle of 180 degrees to the metal panel in a suitable tensile testing machine having a jaw separation rate of 2 inches per minute (0.8 mm/s). During peel strength testing, three cuts shall be made through the sealing compound to the panel in an attempt to promote adhesive failure; these cuts shall be at approximately 1-inch (25-mm) intervals. The results reported shall be the numerical average of the peak loads during cohesive failure. Bond failures between the sealing compound and fabric shall not be included in peel strength values.

4.5.15.5 Repairability: For Classes A-1/2, B-1/4, B-1/2, and C-1/2, two AMS 4045 aluminum alloy panels, 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm), shall be sulfuric acid anodized in accordance with AMS 2471 and coated with MIL-PRF-27725. Apply sealing compound in accordance with 4.5.15.1. After curing at standard conditions for six hours (Class B-1/4) or for 10 hours (Classes A-1/2, B-1/2, C-1/2), immerse the panels in JRF at 77 °F (25 °C) for seven days. Test the panels in accordance with 4.5.15.3 and 4.5.14.4.

4.5.15.6 For Acceptance Tests: Four AMS 4045 aluminum alloy panels, 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm), shall be sulfuric acid anodized in accordance with AMS 2471 and coated with MIL-PRF-27725. Prepare peel panels as specified in 4.5.15.1. Soak two panels in JRF and two panels in JRF/salt water for seven days at 140 °F (60 °C). Test the panels in accordance with 4.5.15.3 and 4.5.15.4.

4.5.16 Chalking: Four, 0.125 x 0.125 x 5 inch (3.18 x 3.18 x 127 mm), specimens shall be cut from a sheet of the sealing compound cured in accordance with 4.5.2.8. The specimens shall be suspended on a nylon cord in a closed glass container with 900 ml of AMS 2629, Type 2 JRF, so that the specimens are totally immersed in the fluid. Aluminum foil shall be used to seal the containers. No metal items shall be in contact with fluid or specimens during the immersion period. Specimens shall not touch each other; all sides of specimens shall be exposed to the fluid. The immersion temperature shall be 77 °F (25 °C). Testing shall be started on a Wednesday; and the JRF shall be changed on the following Friday. Specimens shall be examined for chalking on the following Monday. Remove specimens from the JRF, and allow the fluid to evaporate. Do not blot or wipe the specimens. Inspect strips in a well lighted area. Use an original specimen for comparison with the specimens under test to detect chalking. The rating criteria for sealant chalking are:

a. Slight Chalk Initial observation of white or light gray formation, usually at edges of the sealant.
b. Moderate Chalk The white or light gray formation has spread to approximately one quarter to one half of the surface area.
c. Heavy Chalk The white or light gray formation has spread to approximately three-quarters or more of the surface.

4.5.17 Shear Strength (Classes C and E only): Six AMS 4049 aluminum alloy test panels, 0.040 x 1 x 3 inches (1.02 x 25 x 76 mm), shall be prepared. Apply a coat of sealant 0.010 to 0.020 inch (0.25 to 0.51 mm) thick to one end of three panels, covering approximately 1 inch (25 mm) on each panel. Overlap the sealant with another panel making a 1 square inch (645 mm^2) lap test specimen. Use the jig shown in Figure 4; or use test equipment that is similar to the jig shown in Figure 4. Reduce the sealant thickness to 0.005 to 0.010 inch (0.13 to 0.25 mm). Cure the sealant in accordance with 4.5.2.8. Determine the shear strength by pulling in shear at a speed of 2 inches per minute (0.8 mm/s).

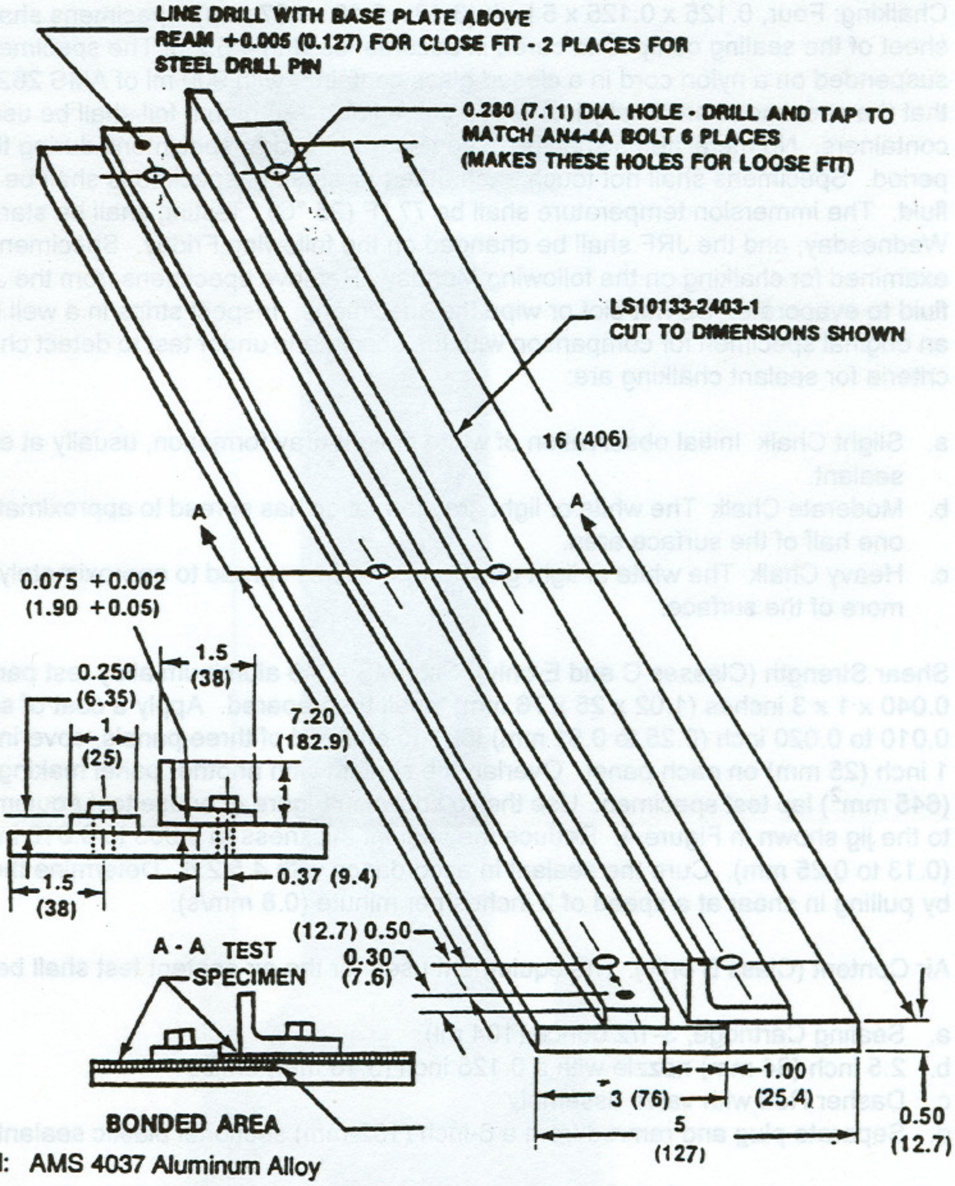
4.5.18 Air Content (Class B only): The equipment used for the air content test shall be as follows:

a. Sealing Cartridge, 3-1/2 ounce (104 ml)
b. 2.5 inch (64 mm) nozzle with a 0.125 inch (3.18 mm) orifice
c. Dasher Rod with valve assembly
d. Separate plug and ramrod from a 6-inch (152-mm) sectional plastic sealant cartridge.

4.5.18.1 The test method shall conform to the following steps and shall refer to Figure 5 for the various steps:

4.5.18.1.1 Test shall be performed at standard conditions as in 4.5.1.1.

4.5.18.1.2 Test sealant conditions shall be stabilized at standard conditions (4.5.1.1) for at least eight hours prior to the test.



NOTES: Material: AMS 4037 Aluminum Alloy

Dimensions are in inches (millimeters).

Unless otherwise specified, tolerances are +/- 0.015 inch (+/- 0.38 mm).

FIGURE 4 - Shear Specimen Fixture

4.5.18.1.3 Fill cartridge with sealant; and prevent air entrapment within the material as the cartridge is being filled. Attach a 2.5-inch (64-mm) nozzle with a 0.125-inch (3.18-mm) orifice to the cartridge. Cut 1.125 inches (28.58 mm) from the tip of the nozzle. Extrude approximately 2 inches (51 mm) of sealant to remove entrapped air.

4.5.18.1.4 Prior to starting the test, the dasher rod should have the seal ring just contacting the dasher end and the valve is open.

4.5.18.1.5 Insert the tip of the filled cartridge firmly into the handle of the dasher rod and deliver sealant slowly until dasher is about three-quarters full. The sealant, however, should completely fill the handle end of the dasher.

4.5.18.1.6 Fill the wider flange side of the plug with sealant and place the plug in the rod behind the sealant with the wide flange side toward the sealant, taking care not to entrap air. Clean off excess sealant.

4.5.18.1.7 Measure the length of the sealant in the dasher in millimeters. Measurements shall be between the interior bottom of the plug and the middle of the curved bead of sealant at the other end of the dasher rod (length OX', as shown in Figure 5).

4.5.18.1.8 Insert the ramrod into the dasher rod and push it until the valve is in the fully-open position, as shown in Figure 5.

4.5.18.1.9 Remove ramrod and clean off any remaining excess sealant at the handle end of the dasher ramrod.

4.5.18.1.10 Slowly push the valve body into the dasher, finally forcing a seal.

4.5.18.1.11 Insert the ramrod into the dasher until it merely touches the top of the plug. Make a mark “B” the ramrod at the handle end of the dasher.

4.5.18.1.12 Put firm hand pressure on the ramrod while the valve end of the dasher is held against a table edge. Make a second mark 'C'.

4.5.18.1.13 Measure the distance between the two marks on the ramrod.

4.5.18.2 The percent of air present in the sealant material can be calculated as shown in Equation 2:

$$\%\ \text{Air Present} = \frac{\text{Distance between marks B and C on the ramrod}}{\text{Original length of the sealant in dasher rod}} \times 100 \qquad \text{(Eq. 2)}$$

4.5.18.3 Three test runs should be made; and the results shall be averaged. Use fresh equipment for each test run.

4.5.18.3.1 Sealant used for compression test shall not be obtained from the top of a drum or container.

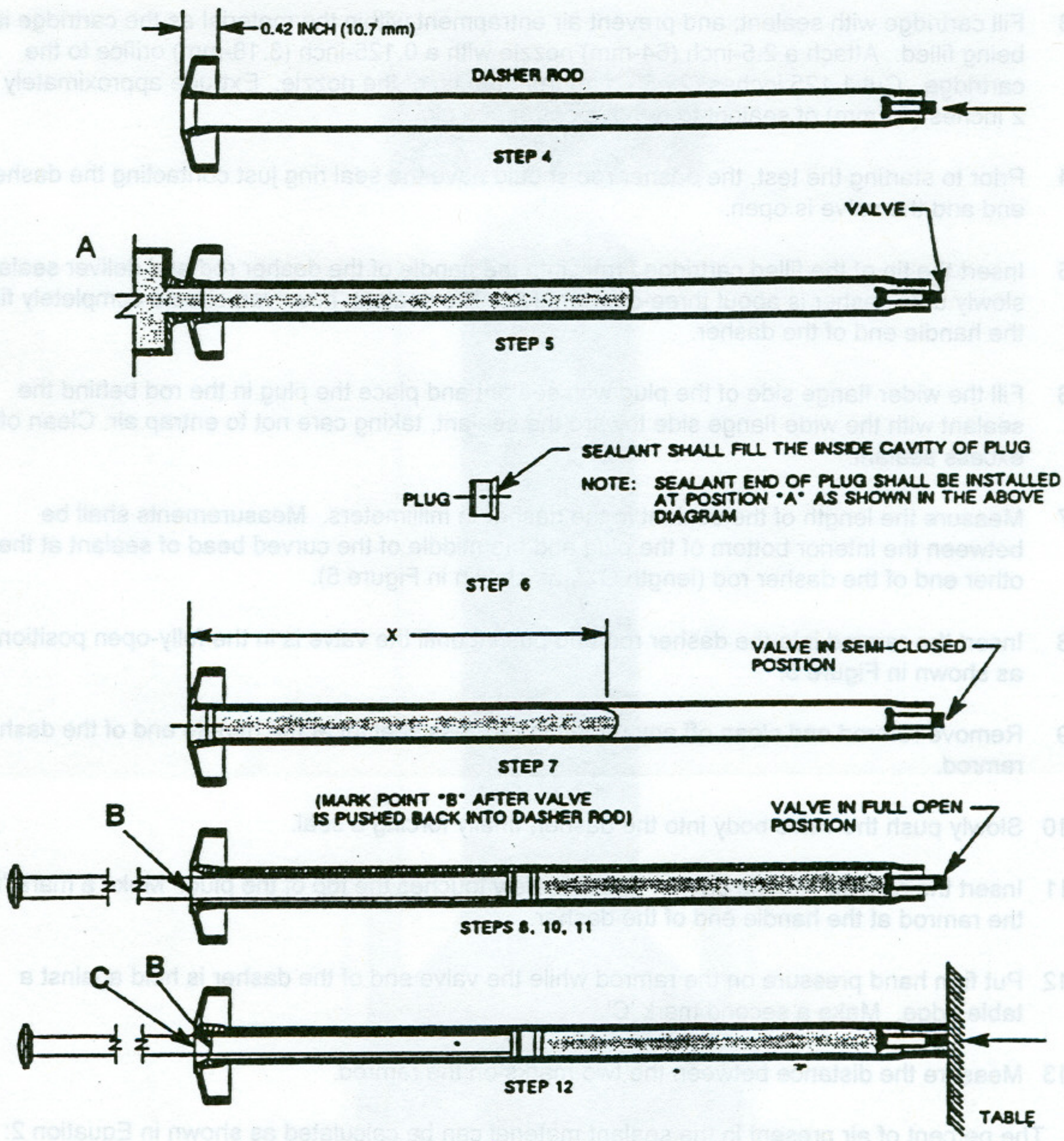


FIGURE 5 - Diagram of Stages in Filling Dasher Rod

4.5.19 Weight Loss, Flexibility, and Swell (Class B Only):

4.5.19.1 Four 0.125 x 1 x 5 inches (3.18 x 25 x 127 mm) specimens shall be cut from a sheet of the sealing compound that has been cured in accordance with 4.5.2.8.

4.5.19.2 Specimens shall be weighed in air (W1) and in water (W2) and then dried. The specimens shall be immersed in 900 ml of JRF for seven days at 140 °F (60 °C) in a closed container. At the end of the exposure period, the specimens shall be removed from the fluid, dipped momentarily in methyl alcohol, and reweighed in air (W3) and in water (W4). Dry the specimens for 24 hours at 120 °F (49 °C); then cool the dried specimens to standard conditions (4.5.1.1) in a desiccator, and weigh them (W5). Percent swell shall be calculated as shown in Equation 3, and percent weight loss shall be calculated in accordance with Equation 4.

$$\text{Percent Swell} = \frac{(W2 + W3) - (W1 + W4)}{(W1 - W2)} \times 100 \qquad \text{(Eq. 3)}$$

$$\text{Percent Weight Loss} = \frac{(W1 - W5)}{W1} \times 100 \qquad \text{(Eq. 4)}$$

4.5.19.3 After weighing, the specimens shall be bent 180 degrees over a 0.125-inch (3.18-mm) mandrel. Visual evidence of cracking or surface checking is not acceptable.

4.5.20 Resistance to Thermal Rupture:

4.5.20.1 Two specimens shall be prepared, each having a fillet of sealing compound, approximately 0.125 inch (3.18 mm) thick by 2 inches (51 mm) in diameter, applied to a test panel of AMS 4045 aluminum alloy. The test panels shall be 0.040 x 3.5 x 3.5 inches (1 x 89 x 89 mm) with a hole in the center of the panel. Diameter of the hole shall be 0.25 inch (6.4 mm); and the hole shall be filled with sealant.

4.5.20.2 The sealing compound fillets shall be cured as in 4.5.2.8 and tests shall begin not more than two days after cure cycle.

4.5.20.3 One of the panels shall be immersed in JRF for 120 hours ± 4 at 140 °F (60 °C), plus 60 hours ± 4 hours at 160 °F (71 °C), and plus 6 hours ± 1 hour at 180 °F (82 °C).

4.5.20.4 The panel shall be removed from the fluid and immediately applied to the fixture, shown in Figure 6, using a suitable gasket. The panel shall be positioned on the fixture such that the sealant is within the fixture chamber.

4.5.20.5 The fixture shall be placed in an oven at 300 °F (149 °C). 10 psi (69 kPa) air pressure shall be applied using an air regulator. The clamp fixture shall be maintained in the oven for a minimum of 30 minutes after pressure is applied.

4.5.20.6 Deformation shall be measured from the surface of the test panel not exposed to pressure, to the point of maximum deformation of the sealing compound.

4.5.20.7 The test shall be repeated on test panels not immersed in JRF.

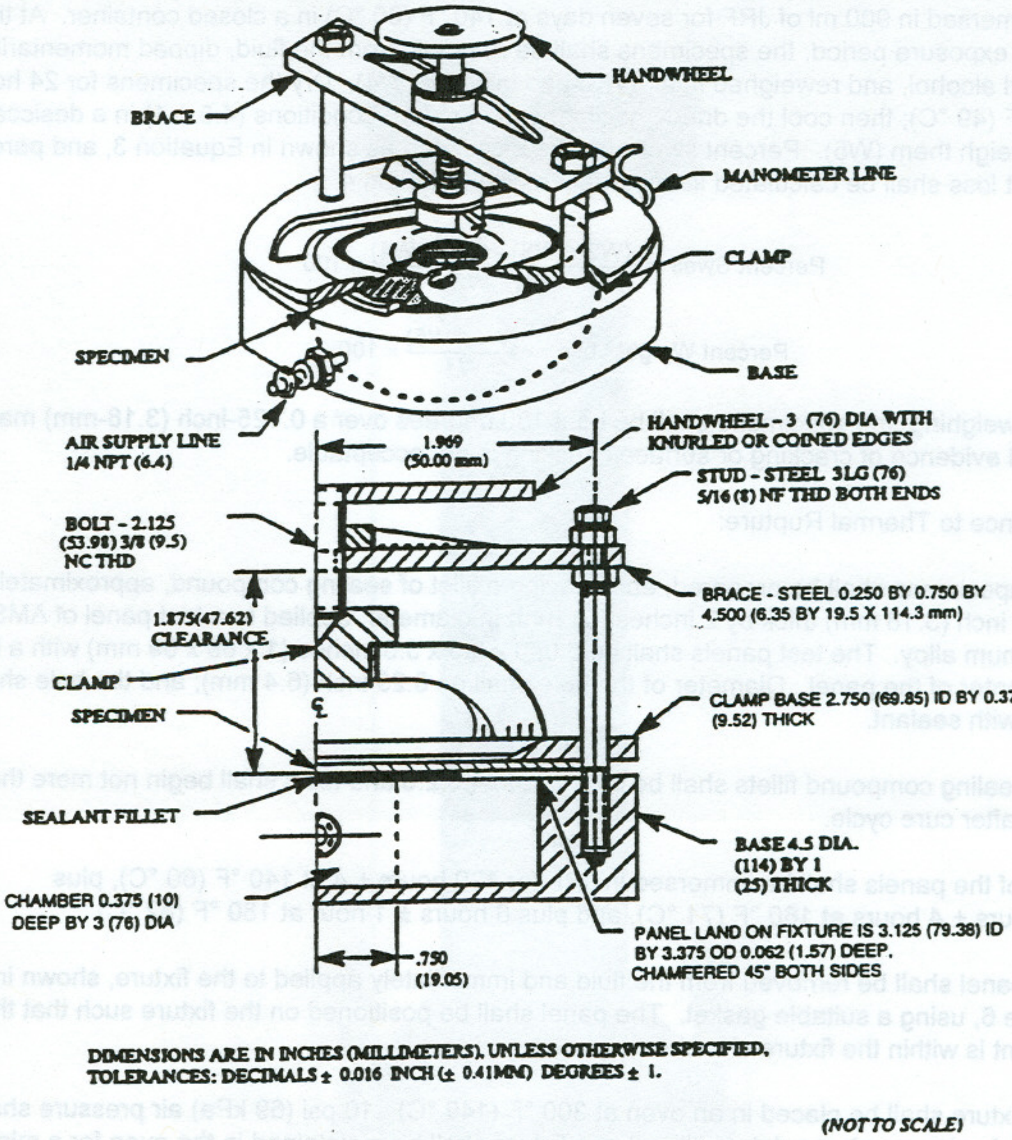


FIGURE 6 - Thermal Rupture Fixture

4.5.21 Resistance to Thermal Expansion: The thermal expansion block shown in Figure 7 shall be anodized in accordance with AMS 2471 and overcoated with MIL-PRF-23377 primer. Fill the groove in the block with sealant. Care shall be taken to prevent air entrapment during filling. The sealant shall be given a standard cure as in 4.5.2.8, and the surface trimmed flush with the block, if necessary. Expose the specimen to a standard heat cycle as in 4.5.1.3, remove from the oven, and measure the amount of sealant expansion at a point located approximately 2 inches (51 mm) from each end of the block. Allow the block to cool to 77 °F (25 °C) and repeat the measurements. The expansion or contraction shall be reported.

4.5.22 Heat Reversion Resistance (Classes B, C, and E only): Use two AMS 4045 aluminum panels, 0.040 x 3 x 12 inches (1.02 x 76 x 305 mm) that are anodized in accordance with AMS 2471 and coated with 0.001 inch (0.025 mm) of MIL-PRF-27725. Select one of these panels; then coat one surface of the selected panel with a continuous layer of freshly-mixed sealing compound -- approximately 0.010 inch (0.25 mm) thick. Place the other panel over the sealant-covered surface to form a sandwich. The panels shall be given a standard cure as is 4.5.2.8; then the panels shall be exposed to a standard heat cycle as in 4.5.1.3. The panels shall be cooled to room temperature and peeled apart in a tensile testing machine at a jaw separation rate of 2 inches per minute (0.8 mm/s) Report the peak load value.

4.5.23 Tensile Strength and Elongation (Classes B (all dash numbers), C-1/2, C-2, C-6, D-1/4 and D-1/2):

4.5.23.1 Mixed sealing compound, 0.125 inch + 0.015 (3.18 mm + 0.4) thick, shall be prepared by pressing between two polyethylene sheets, removing the top sheet at the end of the tack-free time, and allowing the sealing compound to cure as in 4.5.2.8. Twenty-four tensile specimens shall be cut from the sheet using Die C, as specified in ASTM D 412. Three specimens shall be exposed to each of the environmental conditions.

4.5.23.1.1 Standard Cure as in 4.5.2.8:

4.5.23.1.2 JRF soak for 12 days at 140 °F (60 °C), plus 60 hours of soaking in JRF at 160 °F (71 °C), plus six hours of immersion in JRF at 180 °F (82 °C):

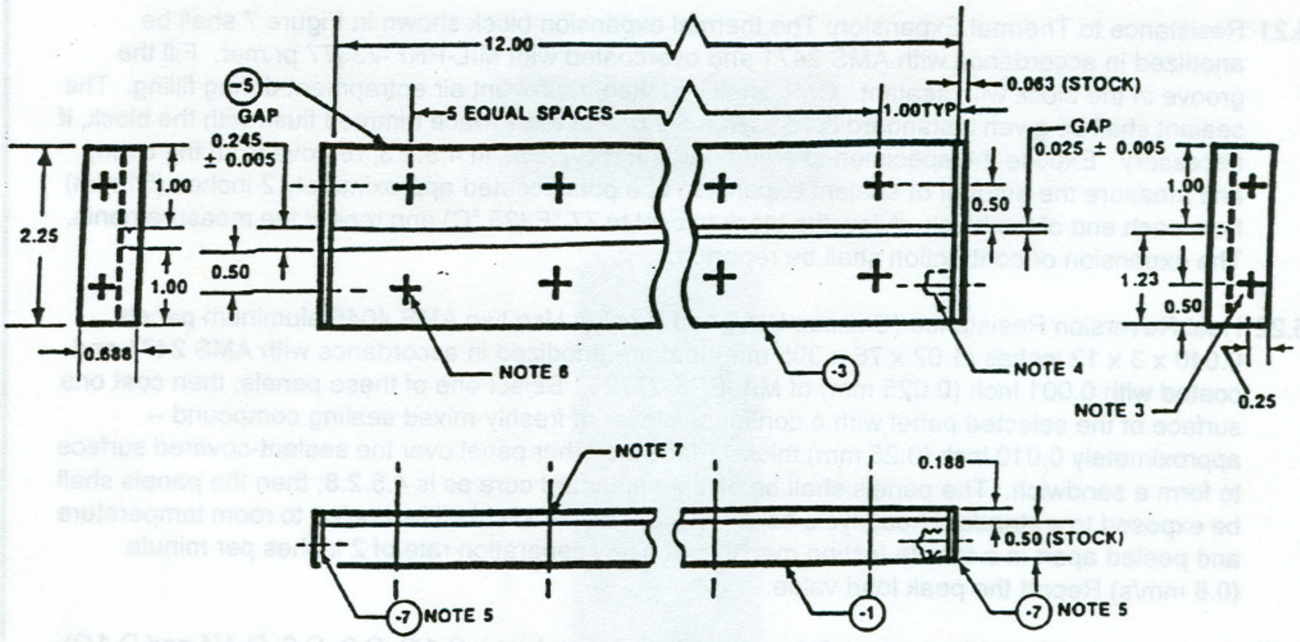
4.5.23.1.3 Condition for 24 hours at 120 °F (49 °C):

4.5.23.1.4 Standard heat cycle as in 4.5.1.3:

4.5.23.1.5 72 hours in AMS 3021 at room temperature:

4.5.23.1.6 72 hours in AMS 3020 at room temperature:

4.5.23.1.7 72 hours in AMS 3021 plus standard heat cycle as in 4.5.1.3:



NOTES:

1. Material: Aluminum alloy, AMS-QQ-A-250/4, temper T81.
2. Tolerances on dimensions: 0.XX = 0.03, 0.XXX = 0.010
3. 0.261 diameter hole two places in each -7.
4. Drill and tap for 1/4-inch bolt, typical two places each end of -1.
5. Attach -7 to -1 with 1/4-inch bolts, four places.
6. Install NAS 1154-10 screw and MS21042-14 nut, 12 places.
7. Install screws 0.005 to 0.020 below surfaces of -3 and -5.
8. Dimensions are in inches (millimeters).

FIGURE 7 - Thermal Expansion Block

4.5.23.1.8 72 hours in AMS 3020 plus standard heat cycle as in 4.5.1.3.

4.5.23.2 Where fluid immersion is specified, the specimens shall be immersed in 400 ml of JRF. Specimens to be tested after fluid immersion shall be cooled, held for 24 hours at 77 °F (25 °C), and tested within five minutes after removal from the fluid.

4.5.23.3 Specimens to be tested after oven aging shall be allowed to cool and held for 16 to 48 hours at standard conditions (4.5.1.1) before testing. Tensile and elongation tests shall be conducted at standard conditions (4.5.1.1), in accordance with ASTM D 412 at a jaw separation rate of 20 inches per minute ± 1 (8.5 mm/s ± 0.4).

4.5.24 Low-Temperature Flexibility: Four AMS 4049 aluminum alloy test panels, 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm), shall be prepared. Apply a coating of sealing compound, 0.1 x 1.5 x 4 inches (2.5 x 38 x 102 mm), to the center of each of the four panels. Maintain an accurate sealant thickness of 0.1 inch (2.5 mm). After a standard cure, as specified in 4.5.2.8, immerse the specimens in 900 ml of JRF for 120 hours ± 4 hours at 140 °F (60 °C) followed by 60 hours ± 4 hours at 160 °F (71 °C) and 6 hours ± 1 hour at 180 °F (82 °C). After fluid exposure, remove specimens from the fluid and expose them to the standard heat cycle (4.5.1.3). Then, immediately place all four panels in a low-temperature flexibility fixture, which consists of a clamp support that grips both of the 6-inch (152 mm) edges of each panel [3 inches (76 mm) from one end] without touching the sealant (see Figure 8). The fixture shall be capable of flexing the panel through a 30-degree arc, 15 degrees each side of center, at a constant speed of one cycle every five seconds (0.2 hertz). Reduce the temperature to -65 °F (-54 °C); and stabilize the specimens at this temperature for at least two hours. Flex the panels through 130 consecutive cycles.

4.5.25 Hydrolytic Stability: A cured specimen, approximately 0.50 inch (12.7 mm) thick x 3 inches (76 mm) in diameter, shall be exposed for 120 days in an environment of 160 °F (71 °C) and 95% ± 5 relative humidity. To obtain this environment, pour a solution of 22% by weight glycerin in distilled water into a desiccator until the liquid level is 1 inch (25 mm) below the desiccator plate. Suspend the sealant specimen in the desiccator so that the specimen does not touch anything. Apply vacuum grease to the lid and slide the lid in place. Loosen the stopper in the hole to prevent vacuum buildup. Place the desiccator in a circulating-air oven set at 158 °F (70 °C) and tightly stopper the hole to prevent water evaporation. Change the glycerin solution every 30 days or whenever it becomes cloudy. After 120 days, remove the desiccator from the oven and allow to cool, frequently loosening the stopper. Remove the specimen from the desiccator and hold at standard conditions (4.5.1.1) for 14 days. Determine the instantaneous durometer hardness in accordance with ASTM D 2240; then report the result.

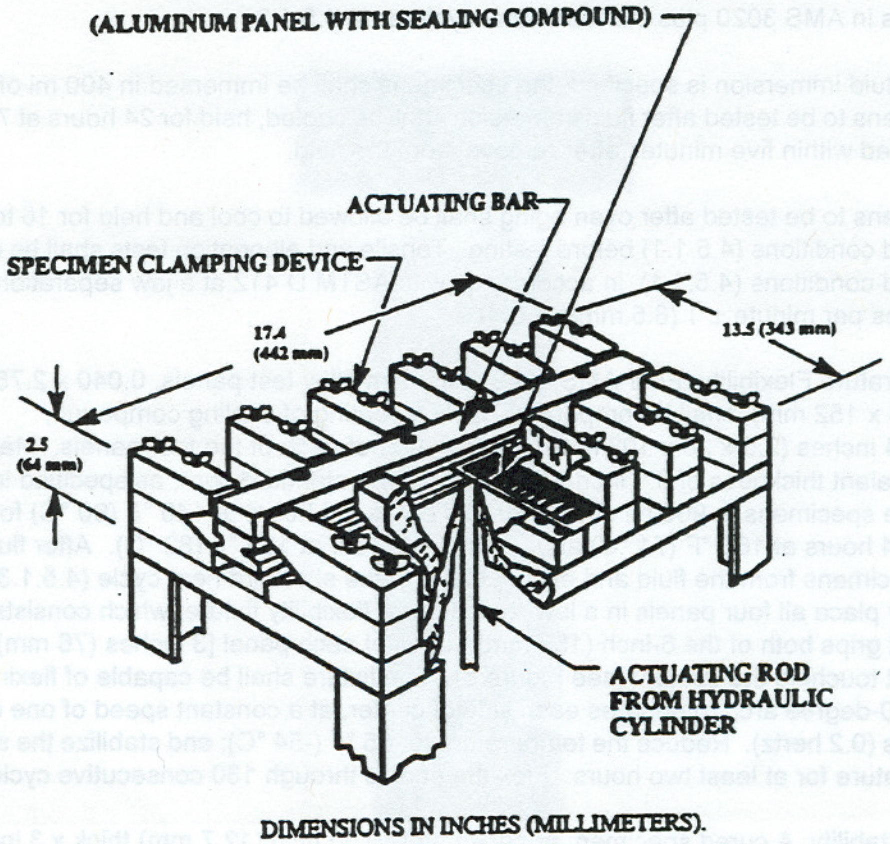


FIGURE 8 - Low-Temperature Flexibility Fixture

4.5.26 Corrosion Resistance: Two AMS 4045 aluminum alloy panels, 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm), shall be prepared as follows:

A controlled area 1 inch (25 mm) wide by 5 inches (127 mm) long shall be masked in the center on one side of each panel. The remainder of the panel shall be chemical conversion coated (see 4.5.2.1) and overcoated with MIL-PRF-27725. After the coating has cured, the manufacturer's recommended adhesion promoter shall be applied; then a 0.062 inch (1.57 mm) thick layer of sealing compound shall be applied to the area, overlapping not less than 0.25 inch (6.4 mm) onto the coated portion. The sealant shall be given a standard cure and the panels conditioned as follows:

a. The panels shall be immersed vertically in a covered glass vessel containing a two-layer liquid consisting of a 3% by weight aqueous sodium chloride solution and JRF so that 2 inches (51 mm) of the panel is exposed to the salt solution, 2 inches (51 mm) is exposed to the JRF, and the remainder of the panel is exposed to the air-vapor mixture.
b. The temperature of the fluid shall be maintained at 140 °F (60 °C) for 12 days, followed by 60 hours at 160 °F (71 °C), and six hours at 180 °F (82 °C).
c. Remove the specimen from the JRF.
d. Immediately remove the sealant from the specimen using a nonmetallic scraper.
e. Examine the surface of the panel for evidence of corrosion.

4.5.27 Repairability:

4.5.27.1 Prepare a sufficient number of AMS 4045 aluminum alloy panels, 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm), so that there are two panels for each Class B-2 sealing compound that is qualified to this specification, plus two panels for sealant being qualification tested to this specification. Sulfuric acid anodize the panels in accordance with AMS 2471; and overcoat the panels with MIL-PRF-27725.

4.5.27.2 Apply adhesion promoter (see 4.5.2.6).

4.5.27.3 Overcoat one side of the panels with 0.125 inch (3.18 mm) of sealing compound, so that two panels are coated with each Class B-2 sealing compound already qualified to this specification, two panels are coated with AMS 3276 polysulfide sealing compound, and two panels are coated with the sealing compound being qualified.

4.5.27.4 After curing for 14 days at standard conditions (4.5.1.1), expose one panel of each sealing compound to AMS 2629, Type 1 JRF for three days at 140 °F (60 °C), followed by three days at 120 °F (49 °C), and seven days at 250 °F (121 °C).

4.5.27.5 Clean all panels in accordance with 4.5.2.5; and apply adhesion promoter (see 4.5.2.6).

4.5.27.6 Apply a 0.125 inch (3.18 mm) thick layer of freshly-mixed sealing compound over the sealing compound that was applied in 4.5.27.3.

4.5.27.7 Prepare a peel strength panel (see 4.5.15).

4.5.27.8 After a standard cure (4.5.2.8), the specimens shall be tested as specified in 4.5.15.

4.5.28 Paintability: Two 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm), AMS 4045 aluminum panels shall be sulfuric acid anodized in accordance with AMS 2471 and coated with MIL-PRF-27725. A thin layer of sealant, approximately 0.031 inch (0.79 mm) thick, shall be applied to one surface and allowed to cure as in 4.5.2.8. After curing, the sealant-coated surface of one panel shall be painted with MIL-PRF-23377 primer. The sealant coated surface of the other panel shall be coated with MIL-PRF-23377 primer and MIL-PRF-85285 polyurethane coating. When the primer and topcoats are fully cured, they shall be soaked in distilled water for 24 hours and wet-tape-adhesion tested in accordance with FED-STD-141, Method 6301.2.

4.5.29 Weather Resistance: A test specimen shall be prepared using a thermal expansion bloc (Figure 7). The entire block shall be finished with MIL-PRF-23377 primer. After this coating is cured, the groove shall be filled approximately flush with sealant. After standard cure of the sealant (see 4.5.2.8), place the test specimen in an Atlas Weatherometer for 30 days. The temperature shall be 140 °F (60 °C); and a cycle of three minutes water spray and 17 minutes sunshine shall be maintained while the specimen is inside the weatherometer. Visually inspect the specimen for evidence of cracking, surface checking, chalking, peeling, or loss adhesion.

4.5.30 Shaving and Sanding (Class B only): The groove and screw heads of a thermal expansion block (Figure 7), coated with MIL-PRF-23377, shall be filled with sealant, allowing a small excess for shaving and sanding. After standard cure, the excess sealing compound shall be removed by shaving with a nonmetallic scraper and by sanding the surface with 400 grit abrasive paper on a sanding block. Visually inspect for rolling or tearing of the sealant.

4.5.31 Radiographic Density:

4.5.31.1 Preparation of Test Panels: A 6-inch (1 52-mm) square plate, 0.25 inch (6.4 mm) thick, shall be prepared from AMS 4049 aluminum alloy. Machine a notch that is 0.25 inch (6.4 mm) wide and 0.125 inch (3.18 mm) deep halfway across the plate. A continuation of this notch shall be milled completely through the remaining half so as to form a slot in the plate.

4.5.31.2 Application of Sealant: Machine mix a sample of the sealant to be tested; then apply a strip of sealant over the entire length of the notched portion and slot in the test plate. Dimensions of the sealant strip shall be 1 inch (25 mm) wide and 0.125 inch (3.18 mm) thick. A mold shall be used during application of the sealant to the plate to ensure uniform thickness of the sealant.

4.5.31.3 Test Procedure: The panel (or plate) prepared in 4.5.31.1 and 4.5.31.2 shall be radiographed in accordance with ASTM E 1742 to obtain a 2% sensitivity through the panel (or plate) at an H & D density of 2.5 ± 0.2, using Dupont 510 or Kodak M film. All density measurements shall be measured with an Ansco-Sweet densitometer.

4.5.32 Storage Stability:

4.5.32.1 Accelerated Storage Stability: A full and tightly closed 1-quart (0.95-L) container of the base compound and a full, tightly closed container of the appropriate amount of curing agent shall be maintained for 14 days at 120 °F (49 °C). After cooling to standard conditions (4.5.1.1) for 24 hours, tests shall be conducted in accordance with 4.5.7, 4.5.8, 4.5.9, 4.5.10, 4.5.11, and 4.5.12. Prepare four AMS 4045 aluminum alloy peel strength test panels, 0.040 x 2.75 x 6 inches (1.02 x 69.8 x 152 mm), sulfuric acid anodized in accordance with AMS 2471 and overcoated with MIL-PRF-27725 (see 4.5.15). The peel test panels shall be aged for seven days at 140 °F (60 °C) with two panels immersed in JRF and two panels immersed in equal parts JRF and 3% by weight aqueous sodium chloride solution. The panels shall be peel strength tested, as in 4.5.15.

4.5.32.2 Long-Term Storage: Three original unopened 1-pint (0.48-L) kits of sealing compounds, 12 fluid ounces (355 ml) of base compound in each kit, and the appropriate amount of curing agent shall be stored at 77 °F (25 °C) for nine months. At the end of the storage period, the sealant shall be tested in accordance with 4.5.9, 4.5.11, and 4.5.12 and inspected to 3.2.28.2.

4.6 Reports:

The supplier (or vendor) of sealing compound shall furnish with each shipment a report showing the test results to determine conformance to the acceptance test requirements and stating that the sealing compound conforms to the other technical requirements. This report shall include the purchase order number, batch number, AMS 3276C, the manufacturer's product (or sealing compound) designation, and quantity.

4.7 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the sealing compound may be based on results from testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet specified Engineering requirements shall be cause for rejection of the sealing compound represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Packaging:

5.1.1 Sealing compound shall be furnished in individual containers for the base compound and the curing agent or in sectional containers. The ratio of the quantity contained in the base compound container to the quantity contained in the curing agent container shall be in accordance with the sealing compound manufacturer's recommended mixing ratio. Adhesion promoter shall be packaged with the sealing compound.

5.1.2 Individual Containers: The base compound shall be furnished in 1/2-pint (236-mL), 1-pint (473-mL), 1-quart (0.95-L), or 1 -gallon (3.78-L) metal cans conforming to PPP-P-704, in 5 gallon (19-L) pails, in 55-gallon (208-L) drums conforming to PPP-D-729, Type 3, except that tin plate cans with paper labels may be used or as specified in the purchase order. The air in base compound containers shall be replaced with nitrogen immediately before closing the containers. The base compound contained in each size container shall be as shown in Table 5.

TABLE 5 - Container Content

Size of Container	Amount of Base Compound
1/2 pint (236 ml)	6 fluid ounces ± 0.125 (178 ml ± 5)
1 pint (473 ml)	12 fluid ounces ± 0.25 (355 ml ± 5)
1 quart (0.95 L)	24 fluid ounces ± 0.5 (710 ml ± 15)
1 gallon (3.78 L)	96 fluid ounces ± 2 (2,840 ml ± 60)
5 gallons (19 L)	5 gallons ± 10 fluid ounces (19 L ± 0.3)
55 gallons (208 L)	50 gallons ± 0.5 (189 L ± 2)

5.1.2.1 The curing compound for kits 1 gallon (3.78 L) or under shall be furnished in glass jars or in suitable containers approved by the purchaser. Glass jars or plastic containers, as applicable, shall have vertical inside walls with no internal projections, rough edges, or internal lips exceeding 0.062 inch (1.57 mm). The glass jars shall be closed with enameled metal or plastic continuous thread screw caps having a nonabsorbent lining material. Caps shall be tightened adequately and further sealed with cellulose bands, or equivalent. Curing agent for 5-gallon (19-L) pails shall be packaged in 1-gallon (3.78-L) cans conforming to PPP-C-96, Type 5, Class 2. Curing agent for 55-gallon (208-L) drums shall be packaged in pails conforming to PPP-P-704.

5.1.2.2 One container each of base compound and curing agent, individually packaged in accordance with 5.1.2, 5.1.2.1, and 5.1.2.2, shall be enclosed in a container acceptable to the purchaser and shall constitute a complete kit.

5.1.3 Sectional-Type Containers: The base compound and curing agent shall be furnished in high-density polyethylene sectional-type 2.5-ounce (74-mL) or 6-ounce (178-mL) cartridges, as specified in the purchase order. The total content of the base compound and curing agent contained in each sectional-type container shall be as shown in Table 6.

TABLE 6 - Container Content

Size of Container	Total Content (Base and Curing Agent)
2.5 ounces (74 ml)	2 fluid ounces ± 0.0125 (69 ml ± 4)
6 ounces (178 ml)	3.5 fluid ounces ± 0.125 (105 ml ± 4)
6 ounces (178 ml)	4.5 fluid ounces ± 0.125 (135 ml ± 4)

5.1.4 Containers of compound shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to handling, packaging, and transportation of the compound to ensure carrier acceptance and sale delivery.

5.2 Identification:

5.2.1 Compound: Each container and each box shall be permanently and legibly marked with not less than the following:

SEALING COMPOUND, POLYSULFIDE (T) SYNTHETIC RUBBER, INTEGRAL FUEL TANKS AND GENERAL PURPOSE, INTERMITTENT USE TO 360 °F (182 °C)
AMS 3276C
MANUFACTURER'S NAME ____________________
MANUFACTURER'S IDENTIFICATION ____________________
BATCH NUMBER ____________________
DATE OF MANUFACTURE ____________________
STORE BELOW 80 °F (27 °C).

5.2.2 Shipping Containers: Each exterior shipping container shall be legibly marked with not less than the following:

SEALING COMPOUND, POLYSULFIDE (T) SYNTHETIC RUBBER, INTEGRAL FUEL TANKS AND GENERAL PURPOSE, INTERMITTENT USE TO 360 °F (182 °C)
AMS 3276C
PURCHASE ORDER NUMBER ____________________
MANUFACTURER'S NAME ____________________
MANUFACTURER'S IDENTIFICATION ____________________
DESCRIPTION ____________________
BATCH NUMBER ____________________
NET WEIGHT ____________________

6. ACKNOWLEDGMENT:

A supplier shall mention this specification number (including its revision letter) and the sealing compound class in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Sealing compound not conforming to this specification, or to modifications authorized by the purchaser, will be subject to rejection.

8. NOTES:

8.1 The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this specification. An (R) symbol to the left of the document title indicates a complete revision of the specification.

8.2 Qualification of Sealing Compound for U.S. Government Procurement:

With respect to sealing compounds requiring qualification, awards will be made only for sealing compounds which are (prior to contract award) qualified for inclusion in the applicable qualified products list (QPL), whether or not such products have been so listed up to that date. Sealant manufacturers are urged to arrange for qualification testing of products covered by this specification in order to ensure eligibility for contract awards and for orders for these materials. The activity responsible for the QPL is the Wright Research and Development Center, ATTN: MLSE, Wright-Patterson Air Force Base, Ohio 45433-6533, and information pertaining to qualification of sealing compound may be obtained from that activity.

8.2.1 Qualification tests shall be performed (and passed) every three years in order to remain on the QPL.

8.3 Purchase documents shall specify not less than the following:

Title, number, and date of this specification
Type and size of containers (kits) desired
Quantity of containers (kits) desired
Special packaging, if required.

8.4 Sealing compounds meeting the requirements of this specification have been classified under Federal Supply Classification (FSC) 8030.

PREPARED UNDER JURISDICTION OF AMS COMMITTEE G-9

NOT MEASUREMENT SENSITIVE

MIL-PRF-81733D
15 May1998
SUPERSEDING
MIL-S-81733C
13 March 1980

PERFORMANCE SPECIFICATION

SEALING AND COATING COMPOUND, CORROSION INHIBITIVE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers accelerated, room temperature curing synthetic rubber compounds used in the sealing and coating of metal components on weapons and aircraft systems for protection against corrosion. The Class 1 sealing compound is effective over a continuous operating temperature range of –65° to +250° F (–54° to +121° C). The Class 2 sealing compound is effective over a continuous operating temperature range of –80° to +320° F (–62° to +160° C).

1.2 Classification. The sealing compound is furnished in the following types, classes, grades, and application times (see 6.2).

1.2.1 Types. The types of sealing compound are as follows:

Type I - For brush or dip application

Type II - For extrusion application, gun or spatula

Type III - For spray gun application

Type IV - For faying surface application, gun or spatula

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division, Code 414100B120-3, Highway 547, Lakehurst, NJ 08733-5100, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 8030
DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

1.2.2 Classes. The classes of sealing compound are as follows:

Class 1 - Polysulfide rubber base material

Class 2 - Polythioether rubber base material

1.2.3 Grades. The grades of sealing compound are as follows:

Grade A - Contains chromate corrosion inhibitors

Grade B - Contains nonchromate corrosion inhibitors

1.2.4 Application time. The minimum application time, in hours, for each type and class is indicated by a dash number as follows:

Type I, Class 1 - Dash numbers are -1/2 and -2

Type I, Class 2 - Dash numbers are -1/4, -1/2, and -2

Type II, Class 1 - Dash numbers are -1/6, -1/4, -1/2, -2, and -4

Type II, Class 2 - Dash numbers are -1/4, -1/2, -2, and -4

Type III, Class 1 - Dash number is -1

Type III, Class 2 - Dash number is -1

Type IV, Class 1 - Dash numbers are -12, -24, -40, and -48

Type IV, Class 2 - Dash numbers are -4, -12, -24, -40, and -48

Example: Type I-1/2 designates a brushable material having an application time of 1/2 hour; Type I-2 designates an application time of 2 hours. All other types and dash numbers are identified in a similar manner.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

A-A-58054	-	Abrasive Mats, Non-Woven, Non-Metallic
L-P-378	-	Plastic Sheet and Strip, Thin Gauge, Polyolefin
QQ-A-250/12	-	Aluminum Alloy 7075, Plate and Sheet
QQ-A-250/13	-	Aluminum Alloy Alclad 7075, Plate and Sheet
QQ-P-416	-	Plating, Cadmium (Electrodeposited)
CCC-C-419	-	Cloth, Duck, Unbleached, Plied-Yarns, Army and Numbered

DEPARTMENT OF DEFENSE

MIL-S-5002	-	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-C-5541	-	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-PRF-5624	-	Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP-8 ST
MIL-PRF-7808	-	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-S-7839	-	Screw, Structural, Aircraft
MIL-A-8625	-	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-T-9046	-	Titanium and Titanium Alloy, Sheet, Strip and Plate
MIL-F-18264	-	Finishes: Organic, Weapons System, Application and Control of
MIL-PRF-23377	-	Primer Coatings: Epoxy, High-Solids
MIL-PRF-23699	-	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-S-38714	-	Sealant Cartridge for Two-Component Materials
MIL-C-38736	-	Cleaning Compound, Solvent Mixtures
MIL-C-81706	-	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-PRF-83282	-	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft

STANDARDS

DEPARTMENT OF DEFENSE

MS24694	-	Screw, Machine, Flat Countersunk Head, 100 Deg., Structural, Cross Recessed, UNC- 3A and UNF-3A

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of the documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AEROSPACE INDUSTRIES ASSOCIATION

NAS679	-	Nut, Self-locking, Hexagon, Low Height

(Application for copies should be addressed to the Aerospace Industries Association, 1250 Eye Street, Washington, DC.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM- A108	-	Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality. (DoD adopted)
ASTM-B117	-	Standard Test Method of Salt Spray (Fog) Testing. (DoD adopted)
ASTM-D412	-	Standard Test Method for Rubber Properties in Tension. (DoD adopted)
ASTM-D2240	-	Standard Test Method for Rubber Property, Durometer Hardness. (DoD adopted)
ASTM-D3182	-	Standard Practice for Rubber Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

SOCIETY FOR AUTOMOTIVE ENGINEERS (SAE)

SAE-AMS2629	-	Fluid, Jet Reference (DoD adopted).
SAE-AMS3819	-	Cloths, Cleaning, For Aircraft Primary and Secondary Structural Surfaces (DoD adopted).
SAE-AMS4376	-	Plate, Magnesium Alloy 3.0A1-1.0Zn-0.20Mn (AZ31B-H26) Cold Rolled and Partially Annealed (DoD adopted).

(Application for copies should be addressed to the Customer Service Department, Publications Group, SAE, 400 Commonwealth Drive, Warrendale, PA 15096.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. The corrosion inhibitive sealing compounds furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.3 and 6.3).

3.2 Material. The basic ingredient used in the manufacture of the Class 1 sealing compound shall be a polysulfide synthetic rubber; the basic ingredient for the Class 2 sealing compound shall be a polythioether synthetic rubber. The sealing compound shall cure by the addition of a separate curing agent to the base compound. Grade B compounds shall contain no chromium or lead compounds.

3.2.1 Soluble chromate compound (Grade A only). Soluble chromate compounds shall be formulated as an integral part of the base compound, the curing system, or both. Any soluble chromate compound shall be permitted provided the base compound, curing agent, and cured compound meet all the requirements contained herein.

3.2.2 Unit of issue. In order to interface with existing equipment and meet the required storage characteristics, the unit of issue for the sealing compound shall be in kits as described below.

Kit Size	Amount of Base Compound	Volume Tolerance
1/2 pint	6 fluid ounces	± 1/8 fluid ounce
1 pint	12 fluid ounces	± 1/4 fluid ounce
1 quart	24 fluid ounces	± 1/2 fluid ounce
1 gallon	96 fluid ounces	± 2 fluid ounces

3.2.2.1 Kits. The base compound and the curing agent shall be packaged in individual containers. The base compound shall be furnished in 1/2-pint, 1-pint, 1-quart, or 1-gallon multiple friction top metal containers as specified by the acquiring activity. The appropriate amount of curing agent shall be furnished in inert, nonmetallic jars having smooth, vertical inside walls with screw caps (to facilitate removal of the curing agent). The air in the unfilled space of the kit shall be replaced with an inert gas (nitrogen or carbon dioxide) immediately prior to closing the container. The ratio of the quantity contained in the base compound container to the quantity contained in the accompanying curing agent container shall be the same as the manufacturer's recommended mixing ratio of the base compound and curing agent. Each curing agent container shall be packaged with one base compound container with a separator between the two containers in a manner which will prevent accidental separation but permit easy separation for mixing purposes.

3.2.2.2 Sectional-type kits (Types I, II, and IV). The base compound and curing agent shall be furnished in sectional-type 2-1/2-ounce or 6-ounce nonmetal containers, conforming to MIL-S-38714, as specified by the acquiring activity. The total amount of base compound and curing agent in each sectional-type container shall be as described below.

Kit Size	Base Compound and Curing Agent	Volume Tolerance
2-1/2 ounces	2 fluid ounces	± 1/8 fluid ounce
6 ounces	3-1/2 fluid ounces	± 1/8 fluid ounce

3.2.3 Marking of component containers. All component containers shall be marked with the date of manufacture and the date of packaging.

3.2.4. Skin contact warning labels. Skin contact warning labels shall be added by the manufacturer.

3.3 Performance characteristics.

3.3.1 Properties before cure.

3.3.1.1 Appearance. The base compound and curing agent shall be of uniform blend and shall be free of skins, lumps, and jelled or coarse particles. There shall be no separation of ingredients which cannot be readily dispersed by mechanical agitation or mixing by hand.

3.3.1.2 Color. Unless otherwise specified in the contract or order, the color of the sealing compound shall be as furnished by the manufacturer (see 6.2). The curing agent, if furnished separately, shall be of contrasting color to facilitate mixing.

3.3.1.3 Nonvolatile content. When tested as specified in 4.8.2, the nonvolatile content of the freshly mixed compound shall be as specified in table I.

TABLE I. Nonvolatile content.

Type	Nonvolatile Content, minimum percent by weight	
	Class 1	Class 2
I	84	84
II	92	92
III	65	65
IV	90	95

3.3.1.4 Flow (Type II only). When tested as specified in 4.8.3, the flow measurement of the sealing compound shall be not less than 0.10 inch and not greater than 0.75 inch.

3.3.1.5 Application life. Application life shall consist of the initial viscosity of the base compound and an application time measurement of the mixed compound (see 4.8.4).

3.3.1.5.1 Initial viscosity. When tested as specified in 4.8.4.1, the initial viscosity of the base compound shall be as specified in table II.

TABLE II. Initial viscosity.

Type	Application	Viscosity, poises
I	Brush or dip	100–500
II	Extrusion or injection, gun or spatula	6,000–16,000
III	Spray	50–150
IV	Faying surface injection, gun or spatula	1,000–4,000

3.3.1.5.2 Application time. When tested as specified in 4.8.4.2, the application time of the compound that is prepared according to the manufacturer's instructions shall be as specified in table III. The end of the application time shall be considered to be not greater than 2,500 poises for Type I, not less than 15 grams per minute for Type II, not greater than 300 poises for Type III, and not less than 30 grams per minute for Type IV, Class 1 or 50 grams per minute for Type IV Class 2.

3.3.1.6 Tack-free time. When tested as specified in 4.8.5, the sealing compound shall cure to a tack-free condition within the time specified in table IV.

TABLE III. Application time.

Type I	Minimum Time, hours	Type II	Minimum Time, hours	Type III	Minimum Time, hours	Type IV	Minimum Time, hours
		-1/6[1]	1/6			-4[2]	4
-1/4[2]	1/4	-1/4	1/4	-1	1	-12	12
-1/2	1/2	-1/2	1/2			-24	24
-2	2	-2	2			-40	40
		-4	4			-48	48

[1] Class 1 only.
[2] Class 2 only.

TABLE IV. Tack-free time.

Type I	Time, hours Class 1	Time, hours Class 2	Type II	Time, hours Class 1	Time, hours Class 2	Type III	Time, hours Class 1	Time, hours Class 2
			-1/6	4	—			
-1/4	-	4	-1/4	8	1	-1	8	8
-1/2	16	8	-1/2	16	2			
-2	24	16	-2	24	12			
			-4	—	24			

3.3.1.7 Assembly time (Type IV only). The sealant shall squeeze out to a thickness no greater than 0.005 inch at the bolts when tested as specified in 4.8.6.

3.3.2 Properties after cure. Unless otherwise specified, all test specimens shall be cured as specified in 4.7.

3.3.2.1 Hardness. When tested as specified in 4.8.7, the Shore A-2 hardness of the cured sealing compound shall be not less than 35 for Types I, II, and III or 30 for Type IV.

3.3.2.2 Specific gravity. When tested as specified in 4.8.8, the specific gravity of the cured sealing compound shall be not greater than 1.65 for Class 1 or 1.50 for Class 2.

3.3.2.3 Corrosion. When tested as specified in 4.8.9, the cured sealing compound shall not in itself induce corrosion and shall protect the substrate metal. There shall be no visible evidence of corrosion at the metal-sealant interface.

3.3.2.4 Low-temperature flexibility. When tested at temperatures and in accordance with the method specified in 4.8.10, the cured sealing compound shall withstand the bend test without cracking, checking, or separating from the panel.

3.3.2.5 Thermal stability. When tested at temperatures and in accordance with the method specified in 4.8.11, the cured sealing compound shall not blister, crack, or show evidence of "blowing" at rest or when wrapped 180° on a mandrel. The hardness, after exposure, shall be within –5 to +15 points of the original "as cured" hardness.

3.3.2.6 Tensile strength (Type II only). The tensile strength of the cured sealing compound shall be not less than 200 pounds per square inch (psi) for Class 1 or 250 psi for Class 2 (see 4.8.12).

3.3.2.7 Elongation (Type II only). The elongation of the cured sealing compound shall be not less than 150 percent for Class 1 or 250 percent for Class 2 (see 4.8.12).

3.3.2.8 Peel strength (Types I, II, and IV). When tested as specified in 4.8.13, the peel strength of the cured sealing compound, as received and after immersion, shall be not less than 15 pounds per inch width (piw) for Class 1 or 20 piw for Class 2. All specimens shall exhibit 100 percent cohesive failure.

3.3.2.9 Anchorage (wet tape test, Type III only). When tested as specified in 4.8.14, the cured sealing compound shall show no more than a slight widening (1/8 inch) of the scratch.

3.3.2.10 Repairability. The cured sealing compound shall be able to be used for repairing minor breaks in itself and all other materials qualified to this specification (see 4.3). A second coat of the sealing compound, applied over a freshly cured coating of the materials specified in 4.8.15, shall show satisfactory bonding with no lifting, blistering, loss of adhesion, or other coating irregularities. When tested as specified in 4.8.15, the adhesion strength of the compound shall be not less than 10 piw for Types I, II, and IV; Type III repairability shall be as specified in 3.3.2.9.

3.3.2.11 Air content (Type II only). When tested as specified in 4.8.16, the air content of the cured sealing compound shall be not greater than 4 percent.

3.3.3 Long-term storage. When tested as specified in 4.8.17, the base compound and curing agent shall show no hardening, separating, or settling of material after being stored for 9 months. After the storage period, the mixed sealing compound shall meet the requirements for flow (3.3.1.4), application life (3.3.1.5), tack-free time (3.3.1.6), and hardness (3.3.2.1).

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.3).
b. Conformance inspection (see 4.4).

4.2 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in the applicable test method or test paragraph in this specification.

4.3 Qualification inspection. Qualification inspection shall consist of all the tests specified in table V.

4.3.1 Samples. Qualification test samples shall consist of 5 quarts of Type I, 8 quarts of Type II, 8 pints of Type III, and 5 quarts of Type IV base compound, together with sufficient curing agent for each type, of the class for which qualification is desired. The samples shall be furnished in units of issue as specified in 3.2.2.

4.4 Conformance inspection. Materials acquired by the Government under this specification shall be source inspected in accordance with 4.4.2 to ensure the material meets the conformance inspection prior to shipment from the manufacturer's plant. Conformance test samples shall be packaged and mixed in, as near as practical, the units of issue as specified in 3.2.2.

4.4.1 Sampling. A 1-quart container or a sufficient number of containers to allow preparation of test specimens shall be randomly selected from each lot and tested as specified in 4.4.2.

4.4.2 Examination. The sample selected in 4.4.1 shall be tested to the requirements specified in table VI. Nonconformance with any specified requirement shall be cause for rejection of the lot represented by the sample.

TABLE V. Qualification tests.

Characteristic	Test Method	Requirement Paragraph	Test Paragraph
Appearance	—	3.3.1.1	4.8.1
Color	—	3.3.1.2	4.8.1
Nonvolatile content	—	3.3.1.3	4.8.2
Flow	—	3.3.1.4	4.8.3
Application life	—	3.3.1.5	4.8.4

TABLE V. Qualification tests.- Cont'd

Characteristic	Test Method	Requirement Paragraph	Test Paragraph
Tack-free time	—	3.3.1.6	4.8.5
Assembly time	—	3.3.1.7	4.8.6
Hardness	ASTM-D2240	3.3.2.1	4.8.7
Specific gravity	—	3.3.2.2	4.8.8
Corrosion	—	3.3.2.3	4.8.9
Low-temperature flexibility	—	3.3.2.4	4.8.10
Thermal stability	—	3.3.2.5	4.8.11
Tensile strength	ASTM-D412	3.3.2.6	4.8.12
Elongation	ASTM-D412	3.3.2.7	4.8.12
Peel strength	—	3.3.2.8	4.8.13
Anchorage (wet tape)	—	3.3.2.9	4.8.14
Repairability	—	3.3.2.10	4.8.15
Air content	—	3.3.2.11	4.8.16
Long-term storage	—	3.3.3	4.8.17
Unit of issue	—	3.2.2	Visual
Warning label	—	3.2.4	Visual

4.5 Test conditions.

4.5.1 Temperature and humidity. Unless otherwise specified, all mixing, curing, conditioning, and testing shall be conducted at a temperature of 77° ± 5° F (25° ± 3° C) and a relative humidity of 50 ± 5 percent. These conditions shall be considered standard conditions.

4.5.2 Mixing. The base compound and its curing agent, both in their original unopened containers, and all required mixing equipment shall be held at standard conditions for 24 ± 1 hours. The base compound and curing agent shall then be thoroughly mixed in the proportions recommended by the manufacturer. Proper care should be taken to avoid incorporation of air by excessive stirring or folding action. Immediately after mixing, Type II sealing compound shall be placed into cartridges for extrusion from the Semco No. 250 gun, or equivalent, having a Semco 440 nozzle with an orifice of 0.125 ± 0.005 inch.

TABLE VI. Conformance tests.

Characteristic	Applicable Type	Test Paragraph
Nonvolatile content	I, II, III, IV	4.8.2
Flow	II	4.8.3
Application life	I, II, III, IV	4.8.4
Hardness	I, II, III, IV	4.8.7
Specific gravity	I, II, III, IV	4.8.8
Thermal stability	I, II, III, IV	4.8.11
Peel strength, initial (Adherend #1)	I, II, IV	4.8.13
Anchorage (wet tape)	III	4.8.14
Unit of issue	I, II, III, IV	Visual
Warning label	I, II, III, IV	Visual

4.6 Preparation of test specimens.

4.6.1 Cleaning of test panels.

4.6.1.1 Aluminum alloys. Unless otherwise specified, aluminum alloy panels shall be cleaned with lint-free cheesecloth conforming to Grade A of SAE-AMS3819, using solvent conforming to MIL-C-38736 or equal, and immediately wiped dry with a clean, lint-free cloth.

4.6.1.2 Other panel materials. All other panels shall be wiped with solvent conforming to MIL-C-38736 or equal, scuffed with abrasive mats conforming to A-A-58054, and cleaned as specified in 4.6.1.1.

4.6.2 Application of sealing compound. Unless otherwise specified, sealing compound shall be applied to test panels to produce a coating thickness, when cured, of 0.125 ± 0.005 inch for Types I, II, and IV and 0.006 ± 0.001 inch for Type III.

4.7 Curing of test specimens. Unless otherwise specified, all test specimens shall be cured as specified in table VII. All molded specimens shall be removed from the mold after the first 24 hours of cure except for Type II-1/6. When specified by the manufacturer, Type IV sealing compound shall be completely covered with polyethylene film conforming to L-P-378 during the entire cure period (see 6.6).

4.8 Test methods.

4.8.1 Examination of product. The base compound and curing agent shall be visually examined for conformance to 3.3.1.1 and 3.3.1.2.

TABLE VII. Standard cure cycle.

Type	Cure Conditions
Class 1, Types I and III	7 days at standard conditions or 24 hours at standard conditions plus 24 hours at 120° ± 2° F (49° ± 1° C)
Class 1, Type II	14 days at standard conditions or 48 hours at standard conditions plus 24 hours at 120° ± 2° F (49° ± 1° C)
Class 1, Type IV	
-12 hour application time	14 days at standard conditions or 24 hours at standard conditions plus 48 hours at 120° ± 2° F (49° ± 1° C)
-24 hour application time	21 days at standard conditions or 24 hours at standard conditions plus 96 hours at 120° ± 2° F (49° ± 1° C)
-40 hour application time	49 days at standard conditions or 24 hours at standard conditions plus 7 days at 120° ± 2° F (49° ± 1° C)
-48 hour application time	56 days at standard conditions or 24 hours at standard conditions plus 9 days at 120° ± 2° F (49° ± 1° C)
Class 2, All Types	14 days at standard conditions or 48 hours at standard conditions plus 24 ± 1 hours at 140° ± 2° F (60° ± 1° C)

4.8.2 Nonvolatile content. Five to 10 grams of the mixed sealing compound shall be transferred to a dish approximately 3.1 inches in diameter. The dish shall be tightly covered immediately and weighed to the nearest milligram. The cover shall then be removed and the sealing compound shall be heated for 72 ± 1 hours at 158° ± 2° F (70° ± 1° C). The compound shall be transferred to a desicator and cooled to room temperature. The dish shall be covered again and weighed to the nearest milligram. The percent nonvolatile content shall be calculated as follows:

$$\text{Percent nonvolatile content} = \frac{\text{Final weight of compound}}{\text{Initial weight of compound}} \times 100$$

4.8.3 Flow (Type II only). A 250-gram lot of sealing compound shall be prepared for testing as specified in 4.5.2. The test shall be conducted by using a flow-test fixture as shown on figure 1. Depth of plunger tolerance is critical and shall be controlled as specified on figure 1.

4.8.3.1 Procedure. The flow-test fixture shall be placed on a horizontal surface with the front face upward and the plunger depressed to the limit of its travel. Within 5 minutes after the

start of mixing for -1/6 material and within 15 minutes for all other dash numbers, the mixed compound shall be added to the recessed cavity of the fixture and leveled off evenly with the block. Within 10 seconds after leveling, the fixture shall be placed on its end and the plunger immediately advanced to the limit of its forward travel. The flow measurement shall be taken directly from the fixture exactly 30 minutes after the sealing compound has been applied to the cavity and shall meet the requirement of 3.3.1.4.

4.8.4 Application life.

4.8.4.1 Initial viscosity. A 1-quart container shall be filled with base compound to within 1/2 inch of the top, covered, and stored at standard conditions for not less than 8 hours. The base compound shall be thoroughly mixed by stirring for 3 minutes and allowed to stand, covered, for 1 hour. The Brookfield Model RVF viscometer, or equivalent, shall be used to determine the viscosity in poises. The spindle and speed required for the test shall be as listed below.

Type	Spindle	Speed
I	No. 6	10 rpm
II	No. 7	2 rpm
III	No. 5	10 rpm
IV	No. 6	2 rpm

4.8.4.2 Application time.

4.8.4.2.1 Types I and III. An amount of base compound and curing agent, sufficient to fill a standard 1/2-pint container (2-7/8 inches in diameter by 2-7/8 inches high) to within 1/2 inch of the top, shall be prepared for testing as specified in 4.5.2. The container shall be tightly covered except when testing the viscosity. At the end of the specified application time (see 3.3.1.5.2), measured from the beginning of the mixing period, the viscosity of the sealing compound shall be determined. The spindle and speed required for the test shall be as listed below.

Type	Spindle	Speed
I	No. 7	10 rpm
III	No. 5	10 rpm

4.8.4.2.2 Types II and IV. The Type II flow-test sample shall be used for Type II material; Type IV material shall be prepared for testing as specified in 4.5.2. From 2 to 3 inches of sealing compound shall be extruded initially to clear trapped air. At the end of the specified application time, measured from the beginning of the mixing period, the sealing compound shall be extruded through a Semco 440 nozzle, or equivalent, with an orifice of 0.125 ± 0.005 inch at 90 ± 5 psig air pressure onto a dish for 1 minute. The weight of the sealing compound shall be determined in grams.

4.8.5 Tack-free time. A test panel, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and measuring approximately 0.04 by 2.75 by 6 inches, shall be cleaned as specified in 4.6.1. Freshly mixed sealing compound shall be applied to the panel, to produce a coating thickness of 0.125 inch for Types I and II and from 0.005 to 0.007 inch for Type III, and cured as specified in 4.7. At the end of the specified tack-free time, two 1- by 6-inch pieces of clean polyethylene film conforming to L-P-378, 0.004 ± 0.002 inch thick, shall be applied to the sealing compound and held in place at a pressure of 0.5 ounce per square inch for 2 minutes. The film shall be slowly and evenly withdrawn at right angles to the sealing compound surface and shall come away clean and free of sealing compound.

4.8.6 Assembly time (Type IV only). Six test panels shall be prepared from aluminum alloy alclad 7075-T6 conforming to QQ-A-250/13 measuring approximately 0.4 by 1.5 by 4 inches. A number 11 drill shall be used to drill two holes in each panel 1.2 inches from one end with centers 0.75 inch apart and 0.375 inch from each side. The panels shall be deburred and cleaned as specified in 4.6.1 and the thickness of the panels around the holes shall be determined. Approximately 0.015 inch of freshly mixed sealing compound shall be applied to the drilled end of three panels and allowed to cure for 1/2 hour. Each of the three remaining clean panels shall be placed on a coated panel so that the holes line up to produce a 1-inch faying surface overlap area. Two steel bolts (10-32) that have been heat treated to 160,000 psi shall be inserted into the holes. The nuts (NAS 679-A3) shall be tightened only until the sealing compound starts to extrude. The thickness of the assembly shall be measured at this time. The thickness of the sandwiched sealing compound shall be from 0.010 to 0.015 inch. The specimens shall be exposed to standard conditions for the following times:

Type IV-4 - 8 hours
Type IV-12 - 24 hours
Type IV-24 - 48 hours
Type IV-40 - 120 hours
Type IV-48 - 168 hours

The fasteners shall then be tightened to a torque value of 40 inch pounds. The thickness of the assembly shall be measured at the fasteners using a micrometer. The thickness of the sealing compound shall be determined by subtracting the panel thicknesses from the overall thickness of the assembly. Conformance to 3.3.1.7 shall be noted.

4.8.7 Hardness. Test specimens shall be prepared and cured as specified in 4.7. Instantaneous hardness (ASTM-D2240) shall be determined on an approximately 0.25-inch thick specimen using a Type A-2 Shore Durometer. Type III specimens shall be cut from a cured ASTM-D3182 standard sheet, or equivalent, and plied to the required thickness.

4.8.8 Specific gravity. Three specimens, measuring approximately 0.03 by 1 by 2 inches, shall be prepared and cured as specified in 4.7. The specimens shall be weighed in air and then in

water by means of an analytical or Jolly balance. The specific gravity shall be computed as follows:

$$\text{Specific gravity (Analytical balance)} = \frac{\text{Weight in air}}{\text{Weight in air - weight in water}}$$

$$\text{Specific gravity (Jolly balance)} = \frac{\text{Weight in air}}{\text{Weight in water}}$$

4.8.9 Corrosion. Corrosion testing shall consist of stressed aluminum assemblies (see 4.8.9.1) and mixed metal assemblies (see 4.8.9.2) undergoing exposure to a corrosive environment.

4.8.9.1 Aluminum assembly preparation. A sufficient number of panels, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and chemically treated with materials conforming to MIL-C-81706 Class 1A to produce coatings conforming to MIL-C-5541, shall be configured to produce test assemblies as shown on figure 2. All surface treatments shall conform to MIL-S-5002. Sealing compound shall be prepared for testing as specified in 4.5.2. Two assemblies shall be used for the corrosion test. Each corrosion test assembly shall be prepared using all four types of sealing compound as specified in table VIII and shall be tested as specified in 4.8.9.3.

4.8.9.2 Mixed metals. All four types of sealing compound shall be subjected to mixed metal corrosion testing. Two assemblies, as specified in table IX and configured as shown on figure 3, shall be used for each sealant.

4.8.9.2.1 Assembly preparation. From 0.005 to 0.007 inch of sealing compound shall be applied to one side of each metal (see figure 3). The coated portions shall be mated using inert nonmetal fasteners tightened to produce a total sealant thickness of approximately 0.007 inch. Excess sealant shall be carefully removed from the panel surface. Type IV sealing compound shall not be mated until 1 to 2 hours after panels are coated.

4.8.9.2.2 Exposure. Mixed metal assemblies shall be exposed as specified in 4.8.9.3.2 and evaluated as specified in 4.8.9.3.3.

TABLE VIII. Aluminum assemblies.

Step	Procedure for Preparation of Aluminum Corrosion Test Assemblies
1	Approximately 0.005 inch of Type IV sealing compound shall be applied to one side of each panel by spatula. After 1 to 2 hours, the coated sides of the panels shall be mated.
2	Threaded fasteners conforming to MIL-S-7839 shall be dipped into Type I sealing compound, inserted into the freshly mated panels, and torqued to 40 inch pounds.
3	Type II sealing compound shall be applied by gun to the butt joint. The fastener head, backs (nuts), and all edges shall be completely covered with compound by using a spatula.
4	Type III sealing compound shall be sprayed over the entire assembly to a thickness of from 0.005 to 0.007 inch.
5	The assembly shall be cured as specified in 4.7 (use the longest cure time based on material used).
6	After curing, one half of the front side of each assembly shall be scribed as shown on figure 2. Assemblies are now ready to be tested.

TABLE IX. Mixed metal assemblies.

Assembly	Metal B (see figure 3)	Metal A (see figure 3)
1	Aluminum[1]	Titanium[2]
2	Aluminum[1]	Magnesium[3]

[1]7075-T6 conforming to QQ-A-250/12 treated with materials conforming to MIL-C-81706 Class 1A.
[2]MIL-T-9046 Type III, Composition C (6 Al - 4V).
[3]SAE-AMS4376, treated with materials conforming to MIL-C-81706 Class 1A.

4.8.9.3 Stress cycling, exposure, and evaluation of assemblies.

4.8.9.3.1 Cyclic loading. Assemblies prepared as specified in 4.8.9.1 shall be installed vertically in the jaws of a machine capable of cycling between 0 and 5,000 pounds for 250 cycles with a loading rate of 10 inches per minute. For Class 1 materials, the assembly shall be subjected to 250 cycles at a temperature of –65° ± 2° F (–54° ± 1° C) after a 30-minute soak at

the same temperature under no load. For Class 2 materials, the assembly shall be subjected to 250 cycles at a temperature of –80° ± 4° F (–62° ± 2° C) after a 30-minute soak at the same temperature under no load.

4.8.9.3.2 Exposure. The prestressed or mixed metal assemblies shall be exposed for a period of 4 weeks in a salt-SO_2 spray cabinet meeting the requirements of ASTM-B117 Appendix 1. The butt joints of Type III and Type IV assemblies shall be masked with wax prior to salt-SO_2 exposure. The test shall be conducted under the following conditions:

Salt solution: 5 percent by weight sodium chloride

Cabinet temperature: 95° ± 2° F (35° ± 1° C)

Saturator tower temperature: 115° ± 2° F (46° ± 1° C)

Cycle: continuous spray; sulfur dioxide injected for 1 hour in every 6 hours (four times daily) at a flow rate of 1cc/min/ft^3 of box.

NOTE: The collected solution in the cabinet shall be tested weekly and shall conform to the following conditions:

1 to 2 ml/hour collection rate

pH of from 2.5 to 3.2

Specific gravity of from 1.02 to 1.04

4.8.9.3.3 Evaluation. The test assemblies shall be removed from the exposure cabinet and disassembled. After the sealant has been carefully stripped from all surfaces, the assembly shall be evaluated for corrosion with respect to sealant function (for example, Type I for fasteners). Countersinks, as well as adjacent areas, and faying surfaces shall be examined under a zoom microscope up to 30X magnification. All surfaces shall be examined for conformance to 3.3.2.3.

4.8.10 Low-temperature flexibility. Three test panels, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and measuring 0.032 by 1 by 6 inches, shall be treated with MIL-A-8625 Type I. Sealing compound shall be applied to one side of each panel to produce a coating thickness of approximately 0.075 inch (from 0.005 to 0.007 inch for Type III) leaving 1 inch at the end of each panel uncoated. Upon completion of the curing time (see 4.7), panels shall be placed in an air-circulating oven and conditioned for 48 ± 1 hours at 250° ± 5° F (121° ± 2° C) for Class 1 and at 320° ± 5° F (160° ± 2° C) for Class 2. The panels shall then be placed in a flexibility fixture as shown on figures 4 and 5 so that the uncoated side touches the contour block and the weight touches only the uncoated end of the panel. The flexibility fixture and Class 1 or Class 2 panels shall be subjected to conditioning temperatures of –65° ± 2° F (–54° ± 1° C) or

−80° ± 2° F (−62° ± 1° C), respectively, for 4 hours. After the specified conditioning, the specimens shall then be bent around the curved portions of the flexibility fixture by releasing the fastening hook. The panels shall be removed and examined for conformance to 3.3.2.4.

4.8.11 Thermal stability. Cured specimens measuring approximately 0.25 by 1 by 2 inches (for Type III, a 0.007-inch cured coating on a panel conforming to QQ-A-250/12 and measuring 0.02 by 1 by 6 inches shall be used) shall be conditioned in an air-circulating oven for 48 ± 1 hours at 250° ± 5° F (121° ± 2° C) for Class 1 and 320°± 5° F (160° ± 2° C) for Class 2. Specimens shall be removed from the oven, returned to standard conditions, and tested for hardness as specified in 4.8.7. (Type III panels shall not undergo hardness testing.) The specimen (including the panel for Type III) shall then be bent through 180° on a 0.25-inch diameter mandrel (0.125 inch mandrel for Type III) and examined while on the mandrel for conformance to 3.3.2.5.

4.8.12 Tensile strength and elongation (Type II only). Molded sheets approximately 0.125 inch thick shall be cured as specified in 4.7. Tensile strength and elongation shall be determined as specified in ASTM-D412 using die C.

4.8.13 Peel strength (Types I, II, and IV).

4.8.13.1 Adherends, cleaning and surface treatment, and immersion media. Test specimens shall be prepared as specified in table X. Cleaning and surface treatment methods for panels shall conform to MIL-S-5002. Immersion media shall be as described below.

Fluid Number	Immersion fluids
1	Hydraulic fluid, MIL-PRF-83282
2	Lubricating oil, MIL-PRF-7808
3	Lubricating oil, MIL-PRF-23699
4	Aqueous sodium chloride solution, 3 percent
5	Turbine fuel, JP-4, MIL-PRF-5624 or Jet Reference Fluid (JRF), SAE-AMS2629

4.8.13.2 Specimen preparation. Adherends, measuring 0.064 by 3 by 6 inches, shall be coated respectively with a 0.125 ± 0.005 inch thickness of Types I, II, and IV sealing compound. A 3- by 6-inch section of a 3- by 12-inch strip of cotton duck conforming to CCC-C-419 Type III or stainless steel wire fabric (20 to 40 mesh) shall be impregnated with the respective types of sealing compounds. The compound must be worked well into the fabric. The sealant-impregnated end of the fabric shall be placed on the coated panel and smoothed down such that air is not trapped beneath the fabric. An additional 0.031-inch-thick coating of Types I, II, and IV sealing compound shall be applied over the fabric. Curing shall be as specified in 4.7.

TABLE X. Adherends.

Panel Number	Adherends	Number of Specimens
1	Aluminum alloy 7075-T6 conforming to QQ-A-250/12, chemically treated with materials conforming to MIL-C-81706 Class 1A.	6
2	Aluminum alloy 7075-T6 conforming to QQ-A-250/12, chemically treated with MIL-A-8625 Type II.	6
3	Cadmium-plated steel (4130) conforming to ASTM-A108 treated in accordance with QQ-P-416 Type II, Class 1.	6
4	Magnesium alloy conforming to SAE-AMS4376 treated with materials conforming to MIL-C-81706 Class 1A.	6
5	Titanium conforming to MIL-T-9046 Type III, Composition C (6 Al - 4V).	6
6	Aluminum alloy 7075-T6 conforming to QQ-A-250/12, chemically treated with MIL-A-8625 Type II, coated with MIL-PRF-23377 and cured 7 days @ standard conditions	6
7	Composite material[1]	6

[1]As specified by the Qualifying activity.

4.8.13.3 Test procedure. After cure, one specimen of each adherend shall be tested at standard conditions and one specimen of each adherend shall be completely immersed for 48 ± 1 hours at 140° ± 2° F (60° ± 1° C) in each of the five immersion test fluids. At the end of the test period, each fluid shall be returned to standard conditions. The specimens shall then be removed and adhesion determined within 10 minutes after removal from the fluids. Two 1-inch wide strips shall be cut lengthwise through the fabric and sealing compound to the panel surface and extended the full length of the loose end of the fabric. The edges of the panel shall not be used as one edge of the test strip. The panels shall be individually tested in an autographic testing machine whose capacity shall be such that the tension at failure is not greater than 85 percent nor less than 15 percent of the full scale load. If the machine is of the pendulum type, the weight shall swing as a free pendulum without engagement of the pawls. The rate of separation of the jaws shall be 2 inches per minute. Specimens shall be mounted in the machine so that the loose end of the 1-inch wide fabric strip will be folded 180° as it is pulled from the panel. Each strip shall be pulled by making a cut through the sealant to the panel at the junction of separation at an angle of 45° in the direction of separation. If the sealant separates from the fabric, similar 45°-angle cuts shall be made to promote separation of the sealant from the panel. A minimum of five cuts shall be made.

The adhesion, in pounds, shall be automatically recorded on a chart as a continuous curve. The adhesion value shall be calculated by averaging the maximum forces required to separate the sealant from the panel. If cohesive failure occurs, the adhesion value shall be recorded as greater than the observed value.

4.8.14 Anchorage (wet tape test, Type III only). A test panel, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and measuring 3 by 6 inches, shall be prepared as specified in 4.6 and tested for wet tape adhesion as specified in MIL-F-18264.

4.8.15 Repairability.

4.8.15.1 Types I, II, and IV. Previously qualified Class 1 and Class 2 materials as well as the sealing compound undergoing qualification testing shall each be used to coat two panels, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and measuring 0.064 by 3 by 6 by inches and treated with materials conforming to MIL-C-81706 Class 1A, to a thickness of 0.125 inch. Curing shall be as specified in 4.7. Panels shall be placed in an air-circulating oven and conditioned for 48 ± 1 hours at 140° ± 2° F (60° ± 1° C) for Class 1 and at 180° ± 2° F (82° ± 1° C) for Class 2. The panels shall be removed from the oven and returned to standard conditions. The sealant shall be cleaned with isopropyl alcohol and air dried for 2 hours. Another coating of freshly mixed sealing compound undergoing qualification testing shall be applied as above over the conditioned sealant. A 3- by 6-inch section of a 3- by 12-inch strip of cotton duck conforming to CCC-C-419 Type III or stainless steel wire fabric (20 to 40 mesh) shall be impregnated with the sealing compound. The compound must be worked well into the fabric. The sealant-impregnated end of the fabric shall be placed on the coated panel and smoothed down such that air is not trapped beneath the fabric. An additional 0.125-inch-thick coating of sealing compound shall be applied over the fabric. After the standard cure (see 4.7), the specimen shall be tested for peel strength as specified in 4.8.13.

4.8.15.2 Type III. Previously qualified Class 1 and Class 2 materials as well as the sealing compound undergoing qualification testing shall each be used to coat a panel, prepared from aluminum alloy 7075-T6 conforming to QQ-A-250/12 and measuring 3 by 6 inches, to a thickness of from 0.005 to 0.007 inch. Curing shall be as specified in 4.7. The panel shall be placed in an air-circulating oven and conditioned for 48 ± 1 hours at 140° ± 2° F (60° ± 1° C). The sealant shall be cleaned with isopropyl alcohol or solvent conforming to table VII and air dried for 2 hours. Another coating of freshly mixed sealing compound undergoing qualification testing shall be applied as above over the conditioned sealant. After the standard cure (see 4.7), each specimen shall be tested for wet tape adhesion as specified in 4.8.14.

4.8.16 Air content (Type II only).

4.8.16.1 Equipment. A sectional-type container, conforming to a Semco 3-1/2-ounce cartridge having a Semco 254 nozzle and Semco dasher rod (6-ounce, No. 220278) with valve assembly, separate plug, and ramrod, shall be used.

4.8.16.2 Procedure. The sealing compound shall be conditioned at standard conditions for a minimum of 8 hours prior to testing as follows:

a. Sealing compound shall be carefully placed in the cartridge, taking care not to introduce air. The Semco 254 nozzle, with 1-1/8 inch cut from the tip, shall be attached to the cartridge and approximately 2 inches of sealant shall be extruded to remove any entrapped air.

b. The dasher rod should have the seal ring just touching the dasher end and the valve is not closed (see figure 6).

c. The tip of the filled cartridge shall be firmly inserted into the handle of the dasher rod and the sealant slowly delivered until the dasher is about three-fourths full. The handle end of the dasher should be completely filled with sealant.

d. The wider flange side of the plug shall be filled with sealant and placed in the rod behind the sealant with the wide flange side toward the sealant, taking care not to entrap air. Excess sealant shall be removed with a gauze pad that has been wet with methyl ethyl ketone.

e. The length of the sealant in the dasher shall be measured in millimeters. Measurements shall be between the interior bottom of the plug and the middle of the curve sealant bead at the other end of the dasher rod (length X, as shown on figure 6).

f. The ramrod shall be inserted into the dasher rod and pushed until the valve is in full open position as shown on figure 6.

g. The ramrod shall be removed and any remaining excess sealant at the handle end of the dasher rod shall be cleaned off.

h. The valve body shall be slowly pushed into the dasher, finally forcing a seal.

i. The ramrod shall be lightly inserted again into the dasher until it just touches the top of the plug. A "B" shall be marked on the ramrod at the handle end of the dasher.

j. Firm hand pressure shall be applied on the ramrod while the valve end of the dasher is held against a table edge. A "C" shall be marked.

k. The distance between the two marks on the ramrod shall be measured.

4.8.16.3 Calculation. The percentage of air present in the sealant shall be calculated as follows:

$$\text{Percent air present} = \frac{\text{Distance between marks B and C}}{\text{Original length X of sealant}} \times 100$$

Three test runs shall be made using fresh equipment for each run and the average results shall be recorded.

4.8.17 Long-term storage. A 1-quart sample of sealing compound and the appropriate amount of curing agent shall be stored for 9 months at 77° ± 6° F (25° ± 3° C). The curing agent shall be stirred if it shows signs of settling or hardening. Failure of the curing agent to return to a smooth, workable consistency shall be construed as a failure. At the end of the storage period, the base compound and the stirred curing agent shall be mixed together and tested for conformance with 3.3.3.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The compounds covered by this specification are used in the production and maintenance of military aircraft exposed for prolonged periods to extreme seagoing environments not encountered by civilian aircraft (see 3.3.2.3 and 4.8.9). Peel strength (see 3.3.2.8) requires immersion in Military fluids. Only compounds identified on the Qualified Products List are used because of the repairability requirement (see 3.3.2.10). The intended use of sealing compounds covered by this specification are for sealing interior and exterior areas on weapons and aircraft systems to protect metal components against corrosion within a service temperature range of –65° to +320° F (–54°C to +160° C) with intermittent use to +400° F (+205°C) depending on the Class of compound selected. The sealing compounds are not intended for use as integral fuel tank sealants.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of this specification.

b. Type, class, grade, and application time required (see 1.2).

c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2 and 2.3).

d. Unit of issue required (see 3.2.2).

e. Quantity required.

f. Color, other than as manufactured (see 3.3.1.2).

g. Packaging requirements (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion on Qualified Products List QPL-81733 whether or not such products have actually been so listed by that date. The attention of contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for products covered by this specification. The activity responsible for the QPL is the Naval Air Warfare Center, Aircraft Division, Code 4.3.4.3, Building 2188, Mailstop 03, 48066 Shaw Road, Patuxent River, MD 20670-5304. Information pertaining to qualification of products may be obtained from that activity.

6.3.1 Inspection reports and manufacturer's data. When authorizing the forwarding of qualification samples, the qualifying activity will request the manufacturer to submit, along with the samples, two copies of the manufacturer's test report containing complete test data showing that the material submitted for qualification conforms to the requirements of this specification, and a copy of the material safety data sheet (MSDS). In addition, two copies of the manufacturer's instructions for preparation, mixing, and application of the sealing compound will be submitted at this time. The samples should be plainly and durably marked with the following information:

Sample for Qualification Test

SEALING AND COATING COMPOUND, CORROSION INHIBITIVE
Specification MIL-PRF-81733D
Type, Class, and Grade
Date of manufacture
Name and address of manufacturer
Plant address which produced the compound
Manufacturer's product identification
Submitted by (name and date) for qualification in accordance with the requirements of MIL-PRF-81733D under authorization (reference authorizing letter).

6.3.2 Retention of qualification. In order to retain qualification of the product approved for listing on the QPL, the manufacturer should verify by certification to the qualifying activity that the manufacturer's product complies with the requirements of this specification. The time of periodic verification by certification will be every 2 years from the date of the qualification certification and will be initiated by the Government. The Government reserves the right to re-examine the qualified product whenever deemed necessary to determine that the product continues to meet any or all of the specification requirements.

6.4 Lot formation. Unless otherwise specified, a lot consists of sealing compound of the same type, class, and grade, produced at one time from one batch, forming a part of one contract or order, and submitted for inspection at one time.

6.5 Toxicity. The sealing compound, when used for its intended purpose, should have no adverse effect on the health of personnel. Questions pertaining to this effect should be referred by the acquiring activity to the appropriate departmental medical service who will act as an adviser to the contracting agency.

6.5.1 Material Safety Data Sheets (MSDS). Contracting officers will identify those activities requiring copies of completed MSDS prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313.

6.6 Curing time. The time and temperature specified as the cure time in 4.7 are for laboratory preparations. These conditions may be considered as the optimum for curing each class of compound. In actual field use, the application time, tack-free time, and cure time will be affected by changes in temperature and humidity. Approximate times for these properties will be halved or doubled when a 10° F increase or decrease, respectively, from the standard temperature is experienced.

6.7 Cross reference. Cross reference information is as follows:

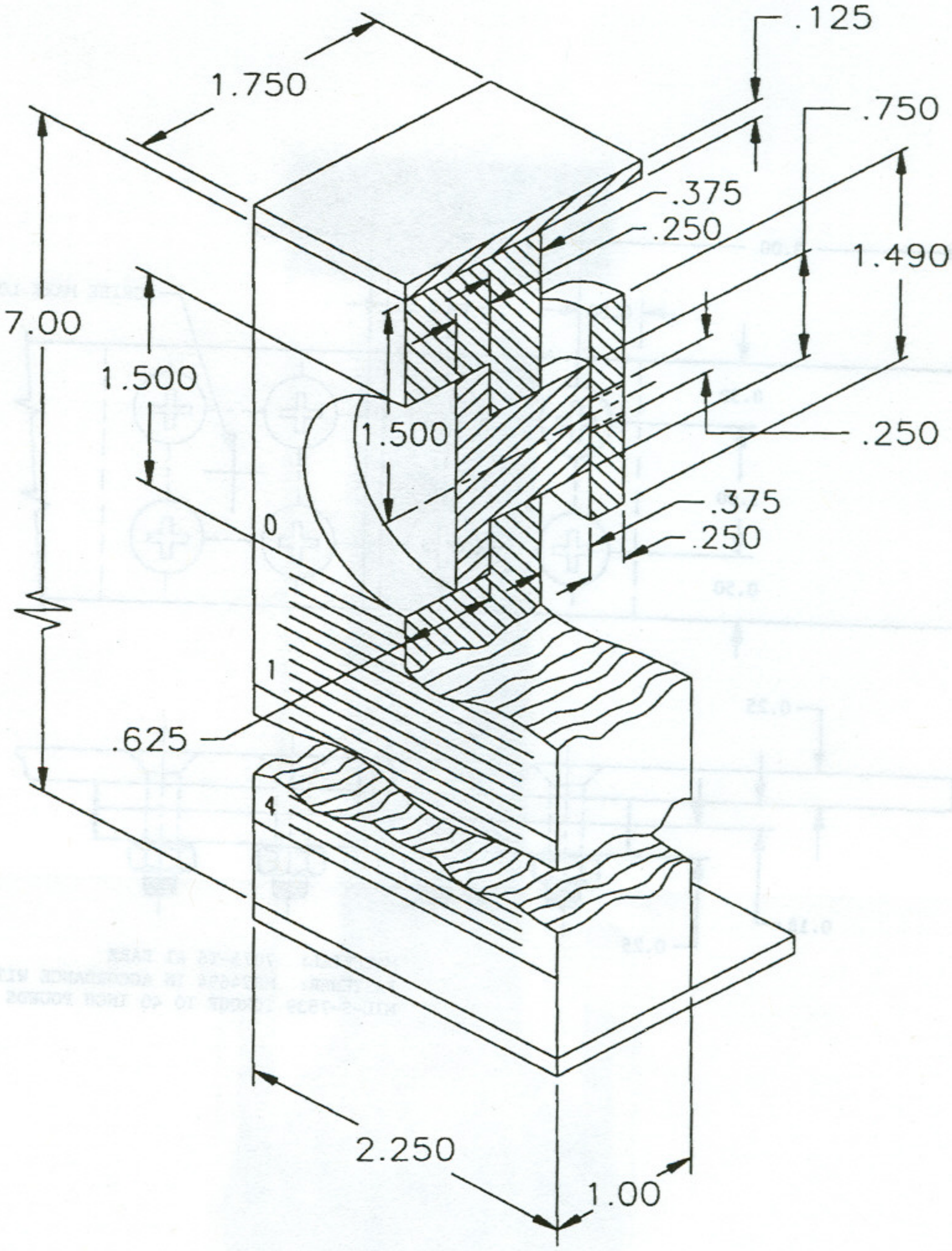
Class 1, Grade A compounds are equivalent to the compounds purchased under MIL-S-81733C.

Class 1, Grade B; Class 2, Grade A and Grade B are new.

6.8 Subject term (key word) listing.

Aircraft
Brush application
Metal protection
Spray application
Synthetic rubber

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.



MATERIALS: 4130 STEEL, CHROMIUM PLATED
DIMENSIONS IN INCHES
TOLERANCES: DECIMALS ± .016

FIGURE 1. Flow-test fixture.

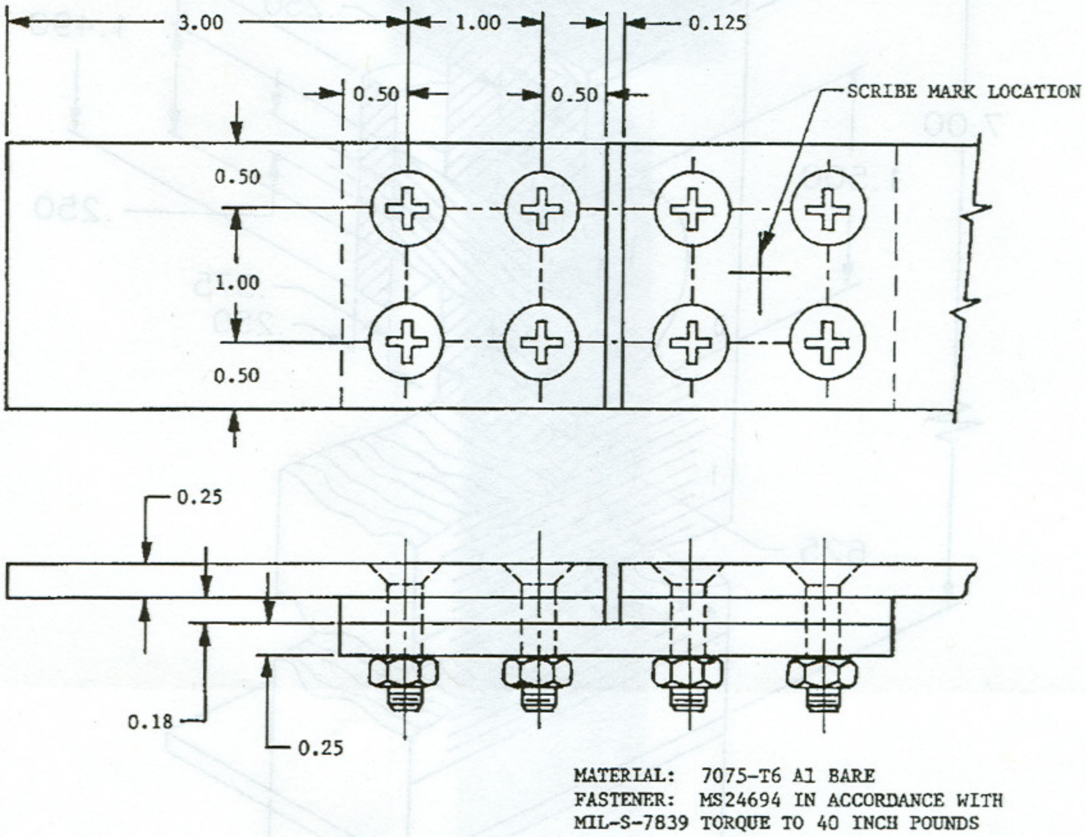
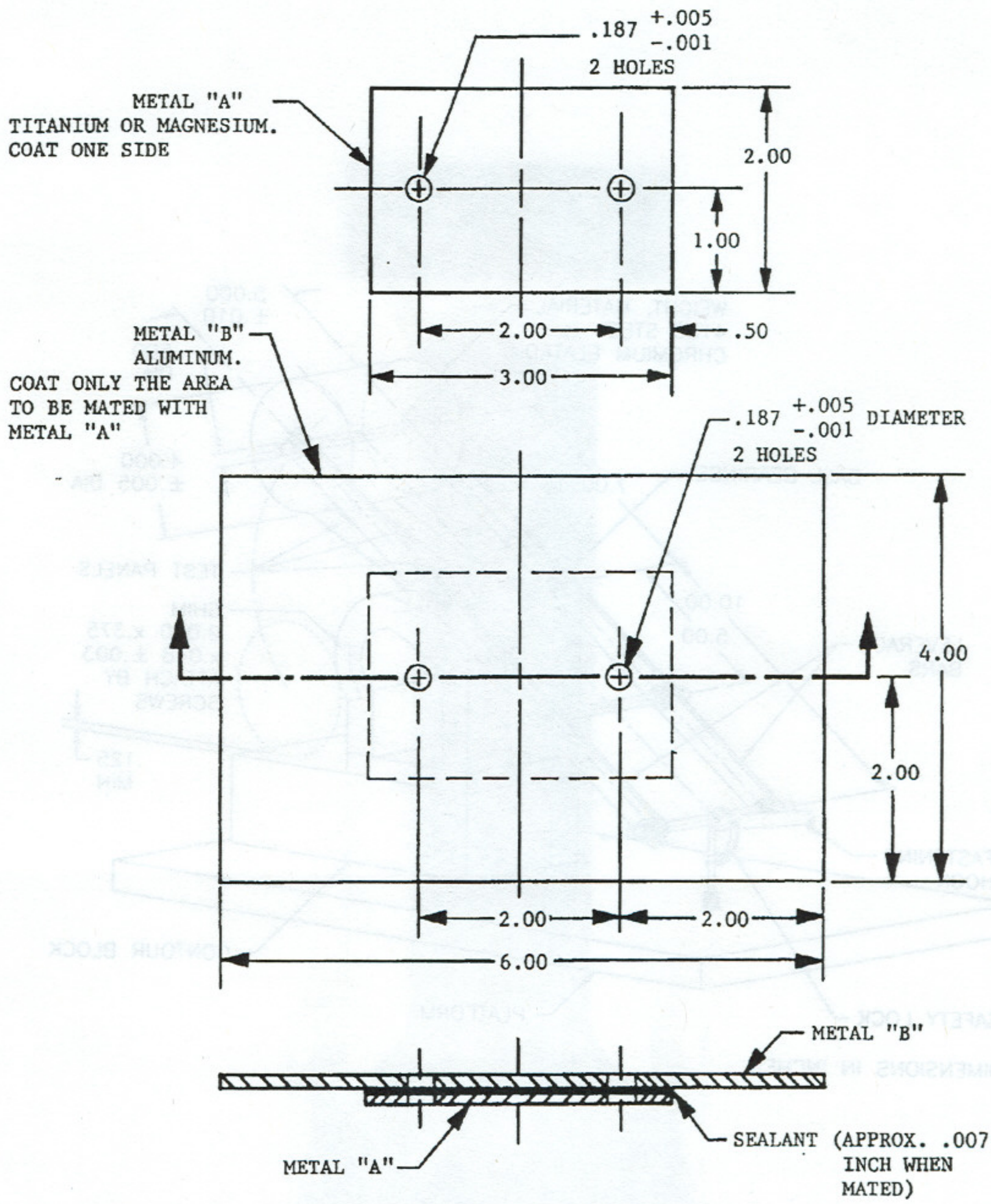


FIGURE 2. Aluminum assembly configuration.



METAL THICKNESS APPROXIMATELY 0.063 INCH
DIMENSIONS IN INCHES
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE APPROXIMATE

FIGURE 3. Mixed metal assembly configuration.

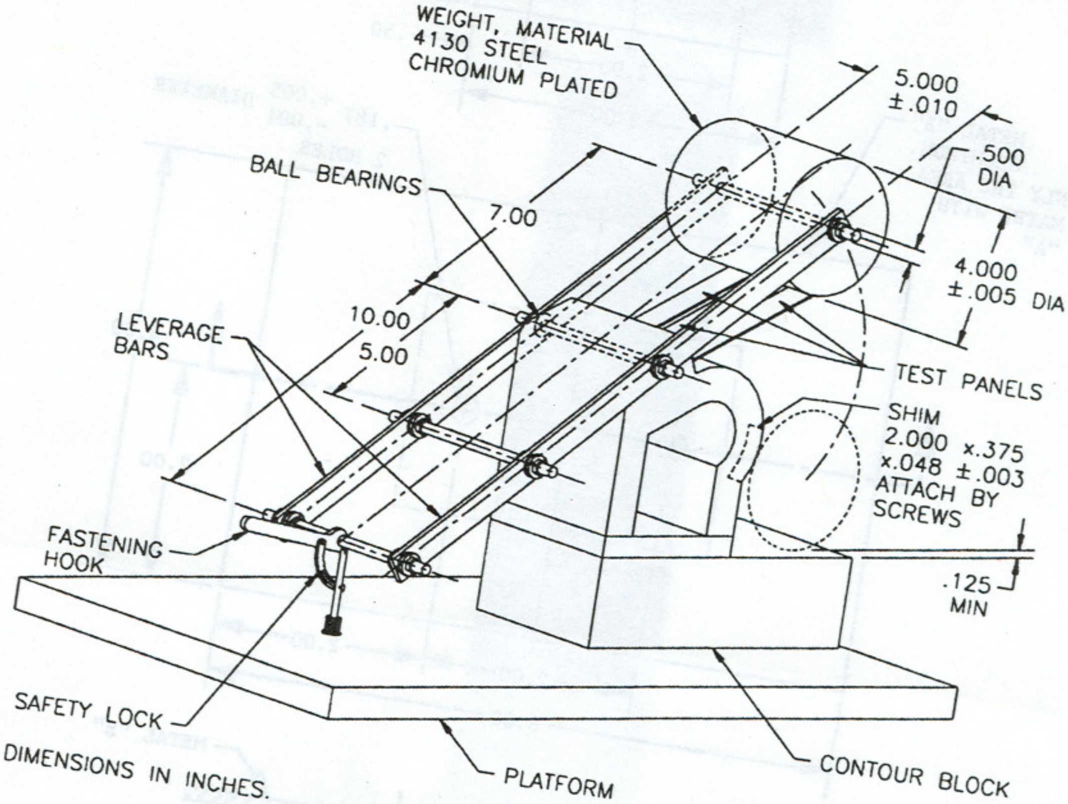


FIGURE 4. Low-temperature flexibility fixture.

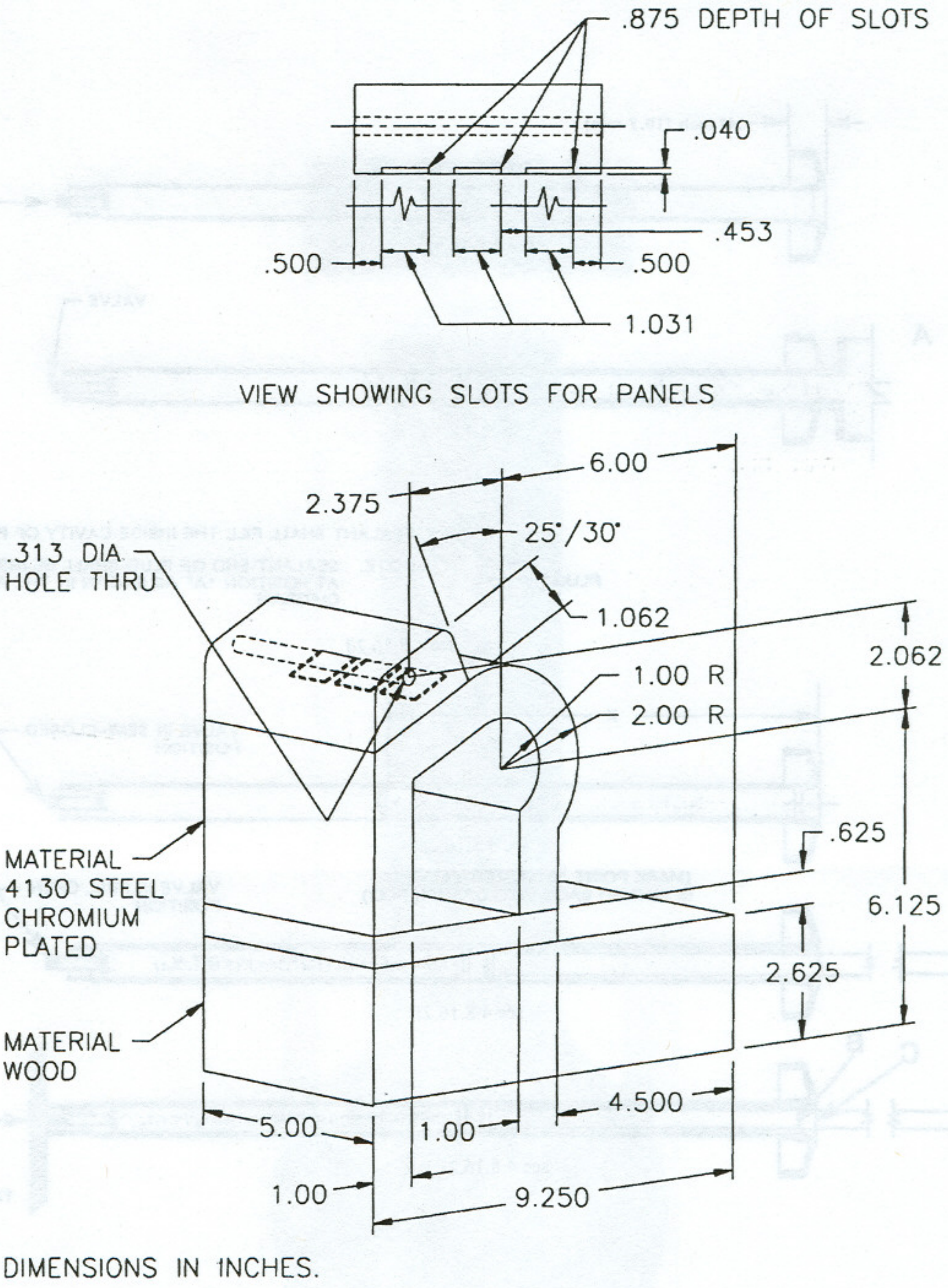


FIGURE 5. Contour block.

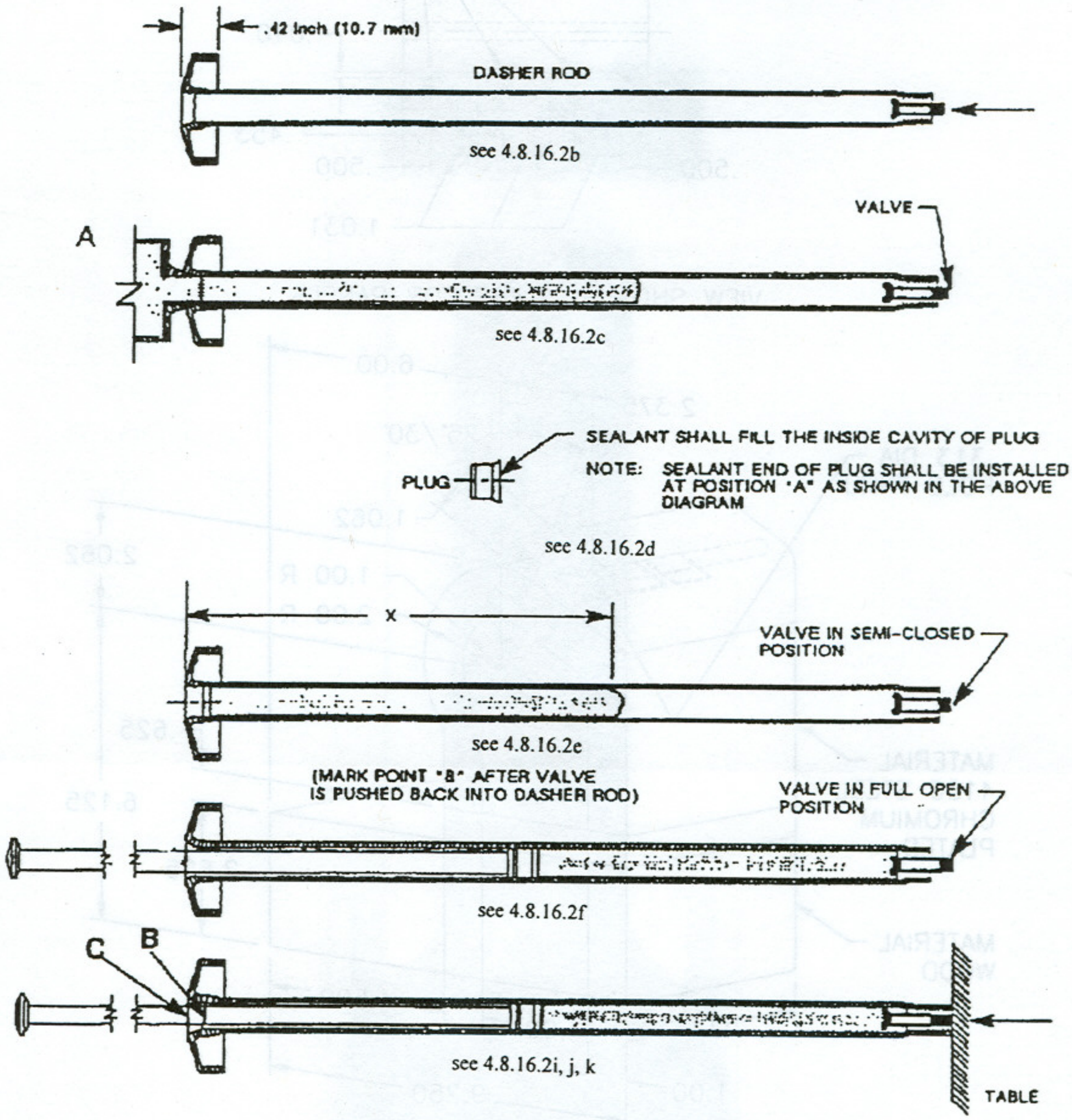


FIGURE 6. Diagram of stages in filling Semco dasher rod.

CONCLUDING MATERIAL

Custodians:
Army - MR
Navy - AS
Air Force - 11

Review activities:
Army - AV, CR4, MI
Navy - MC, YD1
Air Force – 99

Preparing activity:
Navy - AS
(Project No. 8030-0730)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

3. The preparing activity must provide a reply within 30 days from receipt of the form.
NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-PRF-81733D	2. DOCUMENT DATE (*YYMMDD*) 980515

3. DOCUMENT TITLE
SEALING AND COATING COMPOUND, CORROSION INHIBITIVE

4. NATURE OF CHANGE (*Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.*)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (*Last, First, Middle Initial*)	b. ORGANIZATION	
c. ADDRESS (*Include Zip Code*)	d. TELEPHONE (*Include Area Code*) (1) Commercial: (2) DSN: (*If Applicable*)	7. DATE SUBMITTED (*YYMMDD*)

8. PREPARING ACTIVITY

a. NAME COMMANDER NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION	b. TELEPHONE NUMBER (*Include Area Code*) (1) Commercial (732) 323-2947 (2) DSN 624-2947
c. ADDRESS (*Include Zip Code*) CODE 414100B120-3 HIGHWAY 547 LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Logistics Agency (DLSC-LM) Attn: Carla Jenkins/John Tascher 8725 John J. Kingman Road, Ste 2533 Fort Belvoir, VA 22060-6221 Telephone (703) 767-6874

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3277B

Issued APR 1995
Revised JUL 2002

Superseded by AMS 3277A

(R)

Sealing Compound, Polythioether Rubber Fuel Resistant, Fast Curing Intermittent Use to 360 °F (182 °C)

1. SCOPE:

1.1 Form:

This specification covers polythioether rubber sealing compound that is fuel resistant, supplied as a two component system which cures at room temperature.

1.2 Application:

This product has been used typically for contact with fuel, but usage is not limited to such applications. Each application should be considered separately. Polythioether rubber has a service temperature range of –65 to +320 °F (-54 to +160 °C), with short term recurring exposures (approximately 6 hours) to 360 °F (182 °C). It can be used for faying surface and fillet sealing and fastener overcoating. This product is not recommended for use in aerofairing, on aircraft windshields, on canopies or other applications directly exposed to weather. Sealing compound must be applied at temperatures above 50 °F (10 °C), but will cure at lower temperatures.

1.2.1 Notice: This material is mix ratio sensitive and normal mix freeze operations used with polysulfide sealants are not adequate.

1.3 Classification:

Sealing compounds covered by this specification are classified as follows:

Type 1 – Sealing compound requiring an adhesion promoter for proper adhesion. An adhesion promoter is supplied with Type I material and must be applied prior to the sealing compound.

Type 2 – Sealing compound not requiring an adhesion promoter for proper adhesion.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: http://www.sae.org

1.3.1 Both Type 1 and Type 2 sealing compounds shall be supplied in the following classes:

Class A – Suitable for application by brush. Available with the following application times in hours:

A-1/4
A-1/2
A-1
A-2

Class B – Suitable for application by extrusion gun or spatula. Available with the following application times in hours:

B-1/4
B-1/2
B-2

Class C - Suitable for application by brush, extrusion gun, roller or spatula. Used for faying surface sealing only. Available with the following application times in hours:

Notation: ( ) Assembly time in hours.

C-4(4)

1.4 Precautions:

1.4.1 Safety – Hazardous Materials: Shall be in accordance with AS5502 (1.1)

2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been canceled and no superceding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA, 15096-0001, www.sae.org.

AMS 2471 Anodic Treatment of Aluminum Alloys, Sulfuric Acid Process, Undyed Coating
AMS 2629 Fluid, Jet Reference
AMS 3020 Oil, Reference, for "L" Stock Rubber Testing
AMS 3021 Fluid, Reference, for Testing Di-Ester (Polyol) Resistant Material
AMS 3276 Sealing Compound, Integral Fuel Tanks and General Purpose, Intermittent Use to 360 °F (182 °C)
AMS 3819 Cloths, Cleaning For Aircraft Primary and Secondary Structural Surfaces
AMS 4045 Aluminum Alloy Sheet and Plate, 5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr, (7075; -T6 Sheet; -T651 Plate), Solution and Precipitation Heat Treated
AMS 4901 Titanium Sheet, Strip, and Plate, Commercially Pure, Annealed, 70.0 ksi (485 MPa)
AMS 5516 Steel, Corrosion Resistant, Sheet, Strip, and Plate, 18Cr - 9.0Ni (SAE 30302), Solution Heat Treated
AMS-C-27725 Coating, Corrosion Preventative, Polyurethane For Aircraft Integral Fuel Tanks for Use to 250 OF (121 OC)

AS5127 Methods for Testing Aerospace Sealants
AS5127/1 Test Methods for Aerospace Sealants Two-Component Synthetic Rubber Compounds
AS5502 Standard Requirements for Aerospace Sealants

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, www.dsp.dla.mil.

MIL-S-38714 Sealant Cartridge for Two Component Materials - Inactive for new design
MIL-PRF-23377 Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant
MIL-PRF-85285 Coating, Polyurethane, High Solids
MIL-PRF-85582 Primer Coatings: Epoxy, VOC Compliant, Chemical and Solvent Resistant

2.3 PRI Publications:

Available from PRI, 161 Thornhill Road, Warrendale, PA 15086-7527, www.pri.sae.org.

PD 2000 Procedures for an industry Qualified Product Management Process

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

The basic ingredient shall be polythioether synthetic rubber. The sealing compound shall cure by the addition of a curing agent to the base compound, and shall not depend on solvent evaporation for curing. The compound shall contain no lead compounds. The curing agent shall possess sufficient color contrast to the base compounds to permit easy identification of an unmixed or incompletely mixed sealing compound. Neither the base compound nor the cured sealant shall be red or pink in color.

3.1.1 Qualification: All products sold to this specification shall be listed, or approved for listing, on the qualified products list, PRI QPL AMS 3277. The qualified products list shall be in accordance with PD 2000. See AS5502 (2.1)

3.2 Date of Packaging:

Shall be in accordance with AS5502 (3.1)

3.3 Toxilogical Formulations:

Shall be in accordance with AS5502 (3.2)

3.4 Quality: Shall be in accordance with AS5502 (3.3)

3.5 Shelf Life: Shelf life shall be a minimum of 9 months from the date of packaging. Material may be retested for shelf life extension.

3.5.1 Premixed and Frozen Material: Premixed and frozen material shall have a minimum storage life of 30 days at –80 °F (-62 °C) from date of mix/freeze. The date of mix/freeze shall be within the shelf life of the unmixed material.

3.6 Properties:

The sealing compound, when mixed in accordance with manufacturer's instructions and cured as in 4.5.8, shall conform to the requirements shown in Table 1, determined in accordance with specified test methods:

TABLE 1 - Properties

Paragraph	Property	Requirement	Test Method
3.6.1	Nonvolatile Content, (% by weight), min Class A Class B Class C	 84% 96% 95%	AS5127/1 (5.1)
3.6.2	Air Content, max (Class B only)	4%	AS5127/1 (5.2)
3.6.3	Viscosity of Base Compound Class A Class B Class C	 100 to 600 poises (10 to 60 Pa·S) 9000 to 18000 poises (900 to 1800 Pa·S) 1000 to 4000 poises (100 to 400 Pa·S)	AS5127/1 (5.3) Use No.6 spindle at 10 rpm Use No.7 spindle at 2 rpm Use No.6 spindle at 2 rpm
3.6.4	Viscosity of Curing Agent	700 to 1600 poises (70 to 160 Pa·S)	AS5127/1 (5.4) Use No.7 spindle at 10 rpm
3.6.5	Flow (Class B and C only) Class B B-1/4, B-1/2 Initial reading only B-2 Initial, 50 minutes, 90 minutes Class C, min	 0.10 to 0.75 inch (2.5 to 19.0 mm) 0.010 inch (0.25 mm)	 AS5127/1 (5.5) AS5127/1 (5.5.1) AS5127/1 (5.5.2)
3.6.6	Application Time, min		AS5127/1 (5.6)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	Test Method
3.6.6.1	Class A - From the beginning of mixing, the viscosity shall not exceed 2500 poises (250 Pa·s). A-1/4 A-1/2 A-1 A-2	 1/4 hour 1/2 hour 1 hour 2 hours	AS5127/1 (5.6.1) Use No.7 spindle at 10 rpm
3.6.6.2	Class B - From the beginning of mixing, not less than 15 grams per minute shall be extruded. B-1/4 B-1/2 B-2	 1/4 hour 1/2 hour 2 hours	AS5127/1 (5.6.2)
3.6.6.3	Class C - From the beginning of mixing, not less than 30 grams per minute shall be extruded. C-4(4)	 4 hours	AS5127/1 (5.6.2)
3.6.7	Assembly Time, min Class C-4(4)	 4 hours	AS5127/1 (5.7)
3.6.8	Tack Free Time (Measured from the beginning of mixing), max A-1/4, B-1/4 A-1/2, B-1/2 A-1 A-2, B-2 C-4(4)	 1 hour 2 hours 6 hours 12 hours 30 hours	AS5127/1 (5.8)
3.6.9	Cure Time, max (Shore A 25, or equivalent, min)		
3.6.9.1	Standard Cure Time Class A-1/4, B-1/4 Class A-1/2, B-1/2 Class A-1 Class A-2, B-2 Class C-4(4)	 2 hours 4 hours 8 hours 24 hours 48 hours	AS5127/1 (5.9)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	Test Method
3.6.9.2	Low Temperature Cure Time (Classes A and B only, Shore A 25, or equivalent, min) Class A-1/4, B-1/4 Class A-1/2, B-1/2 Class A-1 Class A-2, B-2	 12 hours 24 hours 48 hours 96 hours	AS5127/1 (5.10) Cured at 20 °F (-7 °C)
3.6.10	Fluid immersion Cure Time, max (Shore A 25 or equivalent) Class A-1/4, A-1/2, Class B-1/4, B-1/2	 3 hours 6 hours	AS5127/1 (5.11), except measure hardness after 3 hours (1 hour in fluid), and after 6 hours (4 hours in fluid)
3.6.11	Specific Gravity, max average	1.50	AS5127/1 (6.1)
3.6.12	14 Day Hardness, Durometer Shore A Scale, or equivalent, Instantaneous, min	30	AS5127/1 (6.2)
3.6.13	Radiographic Density Difference between plate and plate plus sealant, max Through sealant in the slot, approximately	 1.00 3.00	AS5127/1 (6.3)
3.6.14	Resistance to Thermal Expansion	Sealant flush with groove within +0.010 and –0.003 inch (+0.25 and –0.08 mm) at the wide end of the test block and within +0.005 and –0.003 inch (+0.13 and –0.08 mm) at the narrow end.	AS5127/1 (6.4) Standard Heat Cycle in accordance with 4.5.3
3.6.15	Heat Reversion Resistance (Class B and C only)	The sealant shall not revert to a liquid or paste-like consistency, nor shall it become brittle or lose adhesion.	AS5127/1 (6.5) Standard Heat Cycle in accordance with 4.5.3
3.6.16	Hydrolytic Stability, min	Shore A 20, or equivalent	AS5127/1 (6.6)
3.6.17	Shaving and Sanding	No rolling or tearing of sealant, smooth finish	AS5127/1 (6.7)
3.6.18	Paintability	No separation from sealant	AS5127/1 (6.8)
3.6.19	Chalking	No chalking	AS5127/1 (7.1)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	Test Method
3.6.20	Resistance to Thermal Rupture	No blistering or sponging, 0.156 inch (0.08 mm) deformation, max	AS5127/1 (7.2) 300 °F (149 °C), 10 psi (69 kPa), 30 minutes
3.6.21	Fluid Rupture Resistance (Class B-1/4 and B-1/2 only)	No JRF or pressure loss	AS5127/1 (7.3)
3.6.22	Resistance to Hydrocarbons		
3.6.22.1	Weight Loss, max	8%	AS5127/1 (7.4)
3.6.22.2	Flexibility	No cracking or checking	AS5127/1 (7.4)
3.6.22.3	Swell	5 to 25%	AS5127/1 (7.5)
3.6.23	Low-Temperature Flexibility	No visual evidence of cracking, checking, or loss of adhesion.	AS5127/1 (7.6) Cure per 4.5.8
3.6.24	Tensile Strength and Elongation (Class B and C), min		AS5127/1 (7.7)
	Standard Cure as in 4.5.8	250 psi (1724 kPa)/250% elongation	
	Standard Cure + 12 days at 140 °F (60 °C) + 60 hours at 160 °F (71 °C) + 6 hours at 180 °F (82 °C), all in JRF	125 psi (862 kPa)/ 100% elongation	
	Standard Cure + 12 days at 140 °F (60 °C) + 60 hours at 160 °F (71 °C) + 6 hours at 180 °F (82 °C) all in JRF + 24 hours at 120 °F (49 °C) + Standard Heat Cycle as in 4.5.3	100 psi (689 kPa)/50% elongation	
	Standard Cure + Standard Heat Cycle as in 4.5.3	100 psi (689 kPa)/125% elongation	
	Standard Cure + 72 hours in AMS 3020	125 psi (862 kPa)/100% elongation	
	Standard Cure + 72 hours in AMS 3021	125 psi (862 kPa)/100% elongation	
3.6.25	Shear Strength, min (Class C only)	200 psi (1379 kPa) average with 100% Cohesive failure	AS5127/1 (7.8)

TABLE 1 - Properties (Continued)

Paragraph	Property	Requirement	Test Method
3.6.26	Corrosion	No corrosion or signs of deterioration	AS5127/1 (7.9)
3.6.27	Peel Strength, min	20 pounds force per inch (3580 N/m) 100% Cohesive failure	AMS 3277 (4.6.1)
3.6.27.1	Peel Strength for Repair Material, min	10 pounds force per inch (1750 N/m) 100% Cohesive failure	AMS 3277 (4.6.1.6)
3.6.28	Repairability, min	5 pounds force/inch (895 N/m), 100% cohesive failure	AMS 3277 (4.6.2)
3.6.29	Storage Stability		AS5127/1 (9.)
3.6.29.1	Accelerated Storage Viscosity of Base Compound Viscosity of Curing Agent Application Time, min Assembly Time, max Tack-Free Time, max Peel Strength, min	 Same as 3.6.3 Same as 3.6.4 Same as 3.6.6 Same as 3.6.7 Same as 3.6.8 Same as 3.6.27	AS5127/1 (9.1)
3.6.29.2	Long-Term Storage, hours (Shore A 25, or equivalent)		AS5127/1 (9.2)

	Application Time min	Tack-Free Time max	Cure Time max
Classes A-1/4, B-1/4	1/4 hour	1.5 hours	3 hours
Classes A-1/2, B-1/2	1/2 hour	3 hours	6 hours
Class A-1	1 hour	6 hours	15 hours
Class A-2, B-2	2 hours	12 hours	30 hours
Class C-4(4)	4 hours	36 hours	60 hours

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Shall be in accordance with AS5502 (4.1).

4.1.1 Source Inspection: Shall be in accordance with AS5502 (4.1.1).

4.1.2 Sampling and Testing: Shall be in accordance with AS5502 (4.3).

4.2 Classification of Tests:

Shall be in accordance with AS5502 (4.2).

4.2.1 Qualification Tests: All technical requirements listed in Table 1 are qualification tests (see 8.2) and shall be performed on the initial production of the sealing compound prior to shipment to a purchaser, when a change in ingredients and/or processing requires reapproval, and when purchaser deems confirmatory testing to be required.

4.2.1.1 Qualification: All products sold to this specification shall be listed, or approved for listing, on the qualified Products List, PRI QPL AMS 3277. The qualified products list shall be in accordance with PD 2000. Class B-2 shall be the first material that is qualified for each supplier of sealing compound in accordance with 8.2. Class B-2 sealing compound shall be tested for, and shall meet all technical requirements of this specification with the exception of requirements unique to other classes of the sealing compound.

4.2.1.2 Once qualification for Class B-2 has been obtained, other classes of the sealing compound may be qualified. The formulation for other classes, and for other Class B application times, shall be the same as Class B-2, except for minor variations necessary for conformance to viscosity and application time requirements. All compounds shall meet all technical requirements of this specification. However, other classes of the sealing compound need only to be tested to the initial acceptance tests listed in Table 2, plus all peel strength tests listed in Table 5, or as defined by purchaser or QPL agency.

4.2.2 Initial Acceptance Tests: Requirements shown in Table 2 are initial acceptance tests and shall be performed on each batch.

TABLE 2 - Acceptance Tests

Test	Requirement Paragraph
Air Content	3.6.2
Nonvolatile Content	3.6.1
Hardness	3.6.12
[1]Viscosity of the Base Compound	3.6.3
[1]Viscosity of the Curing Agent	3.6.4
Flow (Class B only)	3.6.5
Application Time	3.6.6
Assembly Time (C-4(4) only)	3.6.7
Tack-Free Time	3.6.8
Standard Cure Time	3.6.9.1
Fluid Immersion Cure time (A-1/4, B-1/4, A-1/2, B-1/2)	3.6.10
Chalking	3.6.19
Resistance to Thermal Rupture	3.6.20
Weight Loss, Flexibility and Swell	3.6.22
Shear Strength (Class C only)	3.6.25
Peel Strength	3.6.27 and 4.6.1.7

[1]Testing need not be performed on material packaged in sectionalized containers or small size containers less than eight ounces (235 mL).

4.2.3 Final Acceptance Tests: Requirements shown in Table 3 are final acceptance tests and shall be performed on each lot. Acceptance tests of the final packaged product shall consist of the following:

TABLE 3 - Final Acceptance Tests

Test	Requirement Paragraph
Air Content	3.6.2
Application Time	3.6.6
Tack-Free Time	3.6.8
Standard Cure Time	3.6.9.1

4.3 Sampling and Testing: Shall be in accordance with AS5502 (4.3)

4.3.1 For Qualification Tests: Samples shall consist of 80 six-ounce (178-mL) two-component kits with the appropriate amount of adhesion promoter (Type 1 only) plus two 1-quart (1-L) cans. Samples shall be identified as:

SEALING COMPOUND, POLYTHIOETHER, INTEGRAL FUEL TANK AND GENERAL PURPOSE, FAST CURING, INTERMITTENT USE TO 360 °F (182 °C)
AMS 3277, TYPE ________, CLASS ________
MANUFACTURER'S IDENTIFICATION ____________
NAME OF MANUFACTURER ____________________
BATCH/LOT NUMBER____________________
DATE OF PACKAGING____________________
SHELF LIFE EXPIRATION DATE ____________________
STORE BELOW 80 °F (27 °C)

4.3.2 Acceptance Tests: Shall be in accordance with AS5502 (4.3.1)

4.3.2.1 Batch and Lot: A batch shall be defined as the quantity of material run through a mill or mixer at one time. A lot shall be defined as material from one batch of each component assembled (packaged) as finished product in one size and/or type of container at the same time. The lot, when used, shall be traceable to the batches of base compound and curing agent.

4.3.2.2 Initial and Final Acceptance Tests: Each batch shall be subjected to both initial and final acceptance testing. Sufficient material for initial acceptance testing shall be packaged in the same type containers that are being procured. Initial acceptance tests are those listed in Table 2. After successful completion of the initial acceptance tests, the batch shall be released for final packaging. During packaging, test kits shall be selected at random for final acceptance testing. Final acceptance testing is to be conducted on the final packaged product and consist of those tests outlined in Table 3.

4.3.2.3 If the batch is being packaged in different types and/or size containers, the final acceptance tests shall be conducted on each type and/or each size containers. If the sealing compound is being procured under different purchase orders, but the purchase orders call for the same type and size containers, it is only necessary to conduct the final acceptance tests one time.

4.3.2.4 Plastic Injection Kits: Shall be in accordance with AS5502 (4.3.1.3)

4.3.2.5 Cans, Pails, and Drums: Shall be in accordance with AS5502 (4.3.1.4)

4.3.2.6 Both Type Containers: Shall be in accordance with AS5502 (4.3.1.5)

4.3.3 Shelf-Life Surveillance and Updating:

4.3.3.1 Sampling: Shall be in accordance with AS5502 (4.1.2).

4.3.3.2 Shelf-Life Testing: The inspections to be conducted for shelf-life surveillance and updating are listed in Table 4.

TABLE 4 - Shelf-Life Testing

Test	Requirement Paragraph
Appearance	3.1
Viscosity of Base Compound [1]	3.6.3
Viscosity of Curing Agent [1]	3.6.4
Application Time	3.6.6
Tack-Free Time	3.6.8
Standard Cure Time	3.6.9.1
Peel Strength: two aluminum panels, sulfuric acid anodized per AMS 2471, coated with AMS-C-27725 Type II Class B corrosion preventive coating (see 8.6), and aged in AMS 2629, Type I for 7 days at 140°F (60°C).	3.6.27

1. Not possible with sectional-type containers

4.3.3.3 Tests are to be conducted in accordance with test methods outlined herein for acceptance tests. If tests are being performed at the end of the stated shelf life to update the shelf-life of the sealing compound, and all tests are passed, the shelf-life will be extended an additional three months. Up to three updatings is permissible.

4.4 Approval: Shall be in accordance with AS5502 (4.4).

4.5 Test Methods:

4.5.1 Standard Tolerances: Unless otherwise specified herein, standard tolerances of AS5127 (3.1) "Standard Tolerances" shall apply.

4.5.2 Standard Test Conditions: Standard laboratory conditions shall be as specified in AS5127 (4). Test specimens shall be prepared and immediately after completion of preparation, shall be placed under 77 °F (25 °C) and 50 ±5 % relative humidity to cure according to 4.5.8. Except as otherwise directed herein, tests shall be performed at conditions in accordance with AS5127 (4).

4.5.3 Standard Heat Cycle: Standard heat cycle shall consist of the cure cycle of 4.5.8 and the following cycle, which shall be repeated six times.

Four hours at 260 °F (127 °C)
40 minutes ± 5 at 320 °F (160 °C)
One hour at 360 °F (182 °C)
Cool to under 100 °F (38 °C)

4.5.4 Preparation of Test Specimens: Test specimens shall be prepared in accordance with AS5127 (6).

4.5.4.1 Cleaning of Test Panels: Test panels shall be cleaned in accordance with AS5127 (6).

4.5.4.2 Preparation of Peel Strength Test Panels: Test panel configuration shall be in accordance with AS5127/1 (8.) “Peel Strength Properties” and (8.1) “Peel Strength Testing” and as in Figure 22 “Five-Inch Peel Specimen Configuration”.

4.5.5 Preparation of Sealing Compound: Sealing compound shall be prepared in accordance with AS5127 (4.).

4.5.5.1 Acceptance Tests: The quantity of sealing compound required for tests shall be hand-mixed or machine-mixed in accordance with instructions from the manufacturer of the sealing compound. MIL-S-38714 containers shall be used when applicable.

4.5.5.2 Qualification Tests: Sealing compound in sectional-type containers shall be machine mixed.

4.5.6 Application of Adhesion Promoter: For Type 1 compound, the panel surface shall be treated with manufacturer's recommended adhesion promoter, immediately after the panel is cleaned, by wetting a clean AMS 3819, Grade A, cloth with adhesion promoter and wiping the surface. Allow adhesion promoter to air dry for 30 minutes to two hours before applying the sealant. If more than two hours have elapsed, reclean and reapply the adhesion promoter before applying the sealant. Do not use any adhesion promoter for Type 2 compound.

4.5.7 Application of Sealing Compound: Unless otherwise specified herein, freshly mixed sealing compound shall be applied to test panels in accordance with AS5127 (6.8) “Application of Sealing Compound”. For Class A material, a time equal to the application life shall be used between the three applications to permit release of solvents.

4.5.8 Curing of Sealing Compounds: Shall be in accordance with AS5127 (6.9) “Curing of Sealing Compounds.” The sealing compound shall be cured for seven days (except A-1/4, B-1/4. A-1/2, and B-1/2 shall be cured for one day) at standard conditions (4.5.2). An accelerated cure of 24 hours at standard conditions (4.5.2) plus 24 hours at 140 °F (60 °C) may be used for acceptance tests. Tests on the cured sealing compound shall commence not more than two days after the completion of the specified cure.

4.6 Test Procedures: Standard Test Methods are in accordance with AS5127 and AS5127/1. In the event of a conflict between the text of this document and AS5127 and/or AS5127/1, the text of this document takes precedence.

4.6.1 Peel Strength:

4.6.1.1 The type and quantity of panels listed in Table 5 shall be used for the evaluation of peel strength. All panels shall be 2.75 x 6 inches (69.8 x 152 mm). The thickness of the panels shall be as listed in Table 5. The panels shall be prepared in accordance with AS5127 (6.). Sealing compound shall cover 5 inches (127 mm) of one side of the panel surface in accordance with AS5127/1 (Figure 22). When specified, AMS 3100 adhesion promoter shall be applied per 4.5.6 for Type 1 material only.

4.6.1.2 The sealing compound shall be cured in accordance with 4.5.8.

4.6.1.3 At the end of the sealing compound cure, two panels of each substrate listed in Table 5, except those coated with MIL-PRF-23377 primer, MIL-PRF-83285 urethane topcoat, and MIL-PRF-85582 water-based primer, shall be subjected to each of the test conditions listed below:

1. Seven days at 140 °F (60 °C) in AMS 2629, Type I JRF

2. Seven days at 140 °F (60 °C) in equal parts AMS 2629, Type I JRF and 3% by weight aqueous sodium chloride solution

3. 100 hours at 140 °F (60 °C), ten hours at 160 °F (71 °C), one hour at 180 °F (82 °C) in equal parts AMS 2629, Type I JRF and 3% by weight aqueous sodium chloride solution. Repeat cycle five times (six cycles total) using new fluid each time.

4.6.1.4 In addition, two panels of each of the substrates marked with an asterisk (*) in Table 5 shall be subjected to each of the following test conditions:

1. 70 days at 140 °F (60 °C) in AMS 2629, Type I JRF with fluid change every 14 days.

2. 70 days at 140 °F (60 °C) in equal parts AMS 2629, Type I JRF and 3% by weight aqueous sodium chloride solution with fluid change every 14 days.

4.6.1.5 Four panels coated with MIL-PRF-23377 primer (two cured at standard conditions and two cured at 200 °F (93 °C), two of the panels coated with MIL-PRF-85285 urethane topcoat, and two panels coated with MIL-PRF-85582 water-base primer shall be subjected to seven days of 140 °F (60 °C) in a 3% by weight aqueous sodium chloride solution. After specified exposure at 140 °F (60 °C), the panels shall be in the fluid for one day at standard conditions (4.5.2). The peel strength shall be measured within five minutes after removal from the test fluid.

TABLE 5 - Peel Strength Panels

Quantity	Panel Material	Panel Thickness
6	AMS 4045 aluminum alloy conversion coated in accordance with AS5127 (6.1)	0.040 inch (1.02 mm)
6	AMS 4045 aluminum alloy anodized in accordance with AMS 2471	0.040 inch (1.02 mm)
6	AMS 5516 stainless steel	0.025 to 0.040 inch (0.64 to 1.02 mm)
10*	AMS 4901 titanium	0.025 to 0.040 inch (0.64 to 1.02 mm)
10*	AMS 4045 aluminum alloy anodized in accordance with AMS 2471 and coated with AMS-C-27725	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy anodized in accordance with AMS 2471, coated with MIL-PRF-23377, and cured seven days at standard conditions	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy anodized in accordance with AMS 2471, and coated with MIL-PRF-23377, and cured two hours at 200 °F (95 °C)	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy anodized in accordance with AMS 2471 and primed with MIL-PRF-23377, and coated with MIL-PRF-85285 urethane topcoat	0.040 inch (1.02 mm)
2	AMS 4045 aluminum alloy anodized in accordance with AMS 2471, and coated with MIL-PRF-85582 water based primer	0.040 inch (1.02 mm)
6	Graphite/epoxy in accordance with AS5127 (6.5).	0.040 inch (1.02 mm)

*See 4.6.1.4

4.6.1.6 Peel Strength for Repair: For Classes A-1/4, A-1/2, B-1/4, and B-1/2, two 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm) AMS 4045 aluminum alloy panels shall be anodized in accordance with AMS 2471 and coated with AMS-C-27725. Apply sealing compound as in 4.6.1.1. After curing at standard conditions for one hour, immerse the panels in AMS 2629, Type I JRF at 77 °F (25 °C) for seven days. Test the panels in accordance with AS5127/1 (8.).

4.6.1.7 Acceptance Tests: Prepare four, 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm), AMS 4045 aluminum alloy panels, anodized in accordance with AMS 2471, and coated with AMS-C-27725. Prepare peel panel in accordance with AS5127 (6.). Soak two panels in AMS 2629, Type I JRF and two panels in AMS 2629, Type I JRF/salt water for 7 days at 140 °F (60 °C). Test the panels in accordance with AS5127/1 (8.).

4.6.2 Repairability:

4.6.2.1 Prepare a sufficient number of 0.040 x 2.75 x 6 inch (1.02 x 69.8 x 152 mm) AMS 4045 aluminum alloy panels so that there are two panels for each class B-2 sealing compound already qualified, plus two panels for the material being qualified, and two panels for material qualified to AMS 3276. Anodize in accordance with AMS 2471 and overcoat with AMS-C-27725.

4.6.2.2 Apply adhesion promoter in accordance with 4.5.6 (Type 1 materials only) and overcoat one side of the panels with 0.125 inch (3.18 mm) of sealing compound so that two panels are coated with each class B-2 sealing compound already qualified, two panels are coated with AMS 3276 polysulfide sealing compound, and two panels are coated with the sealing compound being qualified. After curing for 14 days at standard conditions in accordance with 4.5.2, expose one panel of each sealing compound to AMS 2629, Type I JRF for three days at 140 °F (60 °C), three days air drying at 120 °F (49 °C), and seven days air aging at 250 °F (121 °C).

4.6.2.3 Clean all panels in accordance with 4.5.4.1, apply adhesion promoter as in 4.5.6 (Type 1 materials only) and apply a thickness of 0.125 inch (3.18 mm) of newly mixed sealing compound over the existing compound. A peel strength panel shall be prepared in accordance with AS5127 (8.). After a standard cure in accordance with 4.5.8, the specimens shall be tested as for peel strength specified in AS5127/1 (8.).

4.7 Reports:

Shall be in accordance with AS5502 (4.5).

4.8 Resampling and Retesting:

Shall be in accordance with AS5502 (4.6).

4.9 Qualification:

See AS5502 (4.7)

5. PREPARATION FOR DELIVERY:

Shall be in accordance with AS5502 (5).

6. ACKNOWLEDGMENT:

Shall be in accordance with AS5502 (6).

7. REJECTIONS:

Shall be in accordance with AS5502 (7).

8. NOTES:

8.1 A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revisions. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

8.2 Qualification of Sealing Compound: See AS5502 (4.7.2) :

8.2.1 Qualification shall be approved every five years in accordance with PD 2000 and the instructions from the Performance Review Institute. See AS5502 (4.7.2.1).

8.3 Properties are divided into two classes: performance (acceptance tests) and application (preproduction or qualification tests) requirements. Performance requirements define those properties of the cured sealant and its performance in service. Application requirements define those properties of the uncured sealant and affect the application parameters of the sealant, but minor variations in application requirements during acceptance testing may not be cause for rejection if approved by the procuring agency.

8.4 Purchase documents should specify not less than the following:

AMS 3277B
Type and class of sealing compound desired
Type and size of containers (kits) desired
Quantity of containers (kits) desired
Special packaging, if required.

8.5 Sealing compounds meeting the requirements of this specification have been classified under Federal Supply Classification (FSC) 8030.

8.6 For information purposes, DeSoto Coating 823-707 in accordance with AMS-C-27725 Type II Class B is recommended for use on peel strength test panels requiring the AMS-C-27725 coating.

8.7 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "G-9"

SUMMARY

Peel strength and Percent cohesive failure AS5127/1 Paragraph 8

Hi Temp Polysulfide Sealant (PR 1440)

Deicer	Lab Sample ID	% Cohesive failure	% failure between paint coating and primer	% failure between paint system and aluminium panel	Peel Strength (N)	Average (N)
Unexposed	03-2061-P (R)	0	0.5 [1]	0	102 [2]	94.0
Unexposed	03-2061-P (L)	0	0.2 [1]	0	86 [2]	
METSS ADF-2	03-2044-P (R)	0	3.4 [1]	0	100% adhesive failure	
METSS ADF-2	03-2044-P (L)	0	0.3 [1]	0	87 [2]	-
Battelle D[3]	03-2053-P (R)	0	0	0	123 [2]	95.5
Battelle D[3]	03-2053-P (L)	0	0	0	68 [2]	
METSS RDF-2	03-2035-P (R)	0	0	0	113 [2]	110.0
METSS RDF-2	03-2035-P (L)	0	0	0	107 [2]	
Clariant Safeway KF Hot	03-2026-P (R)	0	0.9 [1]	0	100 [2]	117.5
Clariant Safeway KF Hot	03-2026-P (L)	0	0.5 [1]	0	135 [2]	
AVIFORM L50	03-2017-P (R)	0	0	0	98 [2]	83.0
AVIFORM L50	03-2017-P (L)	0	0	0	68 [2]	

[1]Probably the result of the cutting tool

[2]This peak value was obtained at the end of peel test as the sample detached from plate. Not the "average of the peak loads during cohesive failure" as required by AS5127/1.

Tests performed on 2003-10-22; test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C

(R) Right side of sample

(L) Left side of sample

Note: Detailed test results are presented in individual reports.

SUMMARY

Peel strength and Percent cohesive failure AS5127/1 Paragraph 8

Polysulfide Sealant (PR 1750)

Deicer	Lab Sample ID	% Cohesive failure	% failure between paint coating and primer	% failure between paint system and aluminium panel	Peel Strength (N)	Average (N)
Unexposed	03-2115-P (R)	0	0	0	100% adhesive failure	
Unexposed	03-2115-P (L)	0	0	0	100% adhesive failure	
METSS ADF-2	03-2097-P (R)	0	1.3 [1]	0	90 [2]	97.5
METSS ADF-2	03-2097-P (L)	0	0.8 [1]	0	105 [2]	
Battelle D^3	03-2106-P (R)	0	0.3 [1]	0	100% adhesive failure	
Battelle D^3	03-2106-P (L)	0	0	0	100% adhesive failure	
METSS RDF-2	03-2088-P (R)	0	2.5 [1]	0	100% adhesive failure	
METSS RDF-2	03-2088-P (L)	0	0	0	100% adhesive failure	
Clariant Safeway KF Hot	03-2079-P (R)	0	0.6 [1]	0	176 [2]	195.5
Clariant Safeway KF Hot	03-2079-P (L)	0	0.3 [1]	0	215 [2]	
AVIFORM L50	03-2070-P (R)	0	0.9 [1]	0	105 [2]	104.5
AVIFORM L50	03-2070-P (L)	0	0.2 [1]	0	104 [2]	

[1]Probably the result of the cutting tool

[2]This peak value was obtained at the end of peel test as the sample detached from plate. Not the "average of the peak loads during cohesive failure" as required by AS5127/1.

Tests performed on 2003-10-22; test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C

(R) Right side of sample

(L) Left side of sample

Note: Detailed test results are presented in individual reports.

SUMMARY

Peel strength and Percent cohesive failure AS5127/1 Paragraph 8

Corrosion Inhibiting Sealant (PS 870)

Deicer	Lab Sample ID	% Cohesive failure (%wire mesh failure)	% Adhesive failure	% failure between paint coating and primer	% failure between paint system and aluminium panel	Peel Strength (Average of the peak loads) (N)	Average (N)
Unexposed	03-2167-P (R)	29 (71)	0	0	0	247	256
Unexposed	03-2167-P (L)	39 (61)	0	0	0	264	
METSS ADF-2	03-2151-P (R)	44 (56)	0	0	0	255	247
METSS ADF-2	03-2151-P (L)	43 (57)	0	0	0	238	
Battelle D³	03-2159-P (R)	39 (61)	0	0	0	278	259
Battelle D³	03-2159-P (L)	43 (57)	0	0	0	240	
METSS RDF-2	03-2142-P (R)[1]	11 (46)	0	0	0	248	248
METSS RDF-2	03-2142-P (L)[1]	26 (74)	0	0	0	248	
Clariant Safeway KF Hot	03-2132-P (R)	65 (35)	0	0	0	285	271
Clariant Safeway KF Hot	03-2132-P (L)	42 (58)	0	0	0	257	
AVIFORM L50	03-2124-P (R)	62 (38)	0	0	0	315	304
AVIFORM L50	03-2124-P (L)	63 (37)	0	0	0	293	

[1]The sample had an unusual shape; there were many porous cavities and the wire mesh was not well adhered to the sealant.
Tests performed on 2003-10-29; test conditions: relative humidity 38 ± 5% and temperature 22 ± 2°C
(R) Right side of sample
(L) Left side of sample
Note 1:**The samples did not meet the AS5127/1 requirement with respect to sealant thickness and width.**
Note 2: Detailed test results are presented in individual reports.

SUMMARY

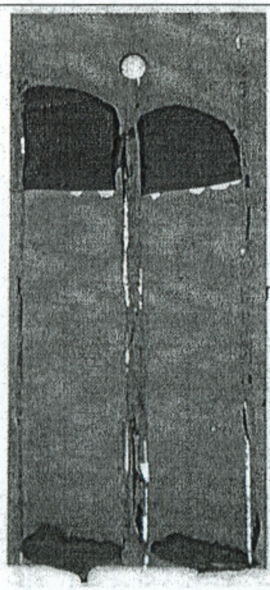
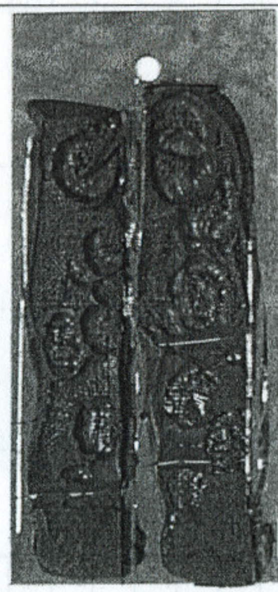
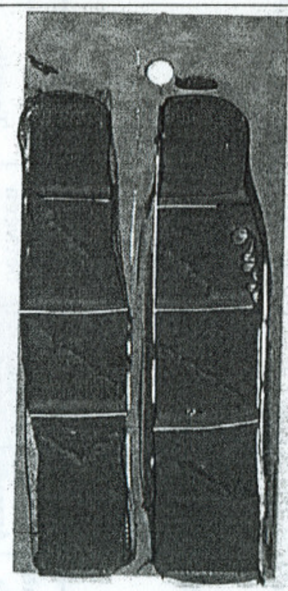
Peel strength and Percent cohesive failure AS5127/1 Paragraph 8

Polythioether Sealant (PR 1826)

Deicer	Lab Sample ID	% Cohesive failure (%wire mesh failure)	% Adhesive failure	% failure between paint coating and primer	% failure between paint system and aluminium panel	Peel Strength (Average of the peak loads) (N)	Average (N)
Unexposed	03-2221-P (R)	48 (52)	0	0	0	214	217
Unexposed	03-2221-P (L)	30 (70)	0	1[1]	0	220	
METSS ADF-2	03-2203-P (R)	21 (79)	0	4[1]	0	285	262
METSS ADF-2	03-2203-P (L)	83 (17)	0	0	0	238	
Battelle D³	03-2212-P (R)	17 (81)	3	2[1]	0	334	324
Battelle D³	03-2212-P (L)	38 (55)	7	5[1]	0	313	
METSS RDF-2	03-2195-P (R)	72 (28)	0	1[1]	0	265	260
METSS RDF-2	03-2195-P (L)	82 (18)	0	1[1]	0	255	
Clariant Safeway KF Hot	03-2185-P (R)	39 (59)	2	2[1]	0	343	337
Clariant Safeway KF Hot	03-2185-P (L)	61 (36)	3	2[1]	0	325	
AVIFORM L50	03-2176-P (R)	75 (24)	0	1[1]	0	260	241
AVIFORM L50	03-2176-P (L)	69 (31)	0	0	0	222	

[1]Probably the result of the cutting tool
Tests performed on 2003-10-29; test conditions: relative humidity 38 ± 5% and temperature 22 ± 2°C
(R) Right side of sample
(L) Left side of sample
Note 1:**The samples did not meet the AS5127/1 requirement with respect to sealant thickness and width.**
Note 2: Detailed test results are presented in individual reports.

Elastomeric Materials – Sealant Peel Strength Photos

Panel ID: 2079 – Polysulfide Sealant exposed to Clariant ®Safeway KF Hot	Panel ID: 2142 – Corrosion Inhibiting Sealant exposed to METSS RDF-2	Panel ID: 2132 – Corrosion Inhibiting Sealant exposed to Clariant ®Safeway KF Hot
		
100% Adhesive Failure	Cohesive Failure	Wire Mesh Failure

SUMMARY

Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus

Nitrile Sheet

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus			
						Tensile $stress_{100\%}$ (MPa)	% El	Tensile $stress_{300\%}$ (MPa)	% El
Unexposed	03-1963-P	15.0	-	10.10	533.8				
Unexposed	03-1965-P					1.4	100		
Unexposed	03-1966-P							5.8	296
METSS ADF-2	03-1949-P	15.5	15.6	10.70	550.4				
METSS ADF-2	03-1950-P	15.6		9.12	555.4				
METSS ADF-2	03-1951-P					1.4	100		
METSS ADF-2	03-1952-P							5.8	300
Battelle D[3]	03-1956-P	15.1	15.4	9.00	536.9				
Battelle D[3]	03-1957-P	15.6		9.88	561.9				
Battelle D[3]	03-1959-P					1.4	100		
Battelle D[3]	03-1960-P							5.9	296
METSS RDF-2	03-1942-P	15.2	15.1	8.60	539.4				
METSS RDF-2	03-1943-P	14.9		8.00	535.2				
METSS RDF-2	03-1945-P					1.4	100		
METSS RDF-2	03-1946-P							5.7	296
Clariant Safeway KF Hot	03-1935-P	15.9	15.9	11.10	563.9				
Clariant Safeway KF Hot	03-1936-P	15.8		10.04	552.2				
Clariant Safeway KF Hot	03-1938-P					1.4	100		
Clariant Safeway KF Hot	03-1939-P							5.7	296
AVIFORM L50	03-1931-P							5.6	296
AVIFORM L50	03-1928-P	16.3	16.1	11.00	576.3				
AVIFORM L50	03-1929-P	15.8		9.00	553.1				
AVIFORM L50	03-1930-P					1.4	100		

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
Tests performed on 2003-09-29 and 2003-10-06; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

SUMMARY
Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus
Neoprene Sheet

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus			
						Tensile $stress_{100\%}$ (MPa)	% El	Tensile $stress_{300\%}$ (MPa)	% El
Unexposed	03-2004-P	8.0	-	12.36	374.7				
Unexposed	03-2006-P					1.7	96		
Unexposed	03-2007-P							5.4	308
METSS ADF-2	03-1990-P	8.7	9.2	14.00	396.3				
METSS ADF-2	03-1991-P	9.6		14.04	426.2				
METSS ADF-2	03-1992-P					1.8	98		
METSS ADF-2	03-1993-P							5.5	308
Battelle D[3]	03-1997-P	9.7	9.7	15.92	440.6				
Battelle D[3]	03-1998-P	9.6		14.04	432.8				
Battelle D[3]	03-1999-P					1.7	96		
Battelle D[3]	03-2000-P							5.4	304
METSS RDF-2	03-1983-P	10.1	9.8	15.64	441.1				
METSS RDF-2	03-1984-P	9.5		13.44	423.9				
METSS RDF-2	03-1985-P					1.7	96		
METSS RDF-2	03-1986-P							5.4	308
Clariant Safeway KF Hot	03-1976-P	10.3	9.5	15.08	440.6				
Clariant Safeway KF Hot	03-1977-P	8.6		13.24	390.2				
Clariant Safeway KF Hot	03-1978-P					1.8	96		
Clariant Safeway KF Hot	03-1979-P							5.7	304
AVIFORM L50	03-1969-P	9.9	9.6	16.00	432.1				
AVIFORM L50	03-1970-P	9.2		12.00	407.2				
AVIFORM L50	03-1971-P					1.7	96		
AVIFORM L50	03-1972-P							5.6	308

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
Tests performed on 2003-09-30, 2003-10-02 and 2003-10-06; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

SUMMARY
Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus
Hi Temp Polysulfide Sealant

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus			
						Tensile stress$_{100\%}$ (MPa)	% El	Tensile stress$_{300\%}$ (MPa)	% El
Unexposed	03-2055-P	3.8	3.6	1.68	253.1				
Unexposed	03-2056-P[3]	3.3		1.56	219.7				
Unexposed	03-2057-P					1.8	96		
Unexposed	03-2058-P							2.7	180
METSS ADF-2	03-2037-P[3]	2.6	2.3	0.40	184.0				
METSS ADF-2	03-2038-P[3]	1.9		0.00	140.2				
METSS ADF-2	03-2040-P[3]	2.3		0.00	169.0				
METSS ADF-2	03-2039-P[3]					1.7	96		
Battelle D[3]	03-2046-P[3]	3.6	3.7	2.00	253.6				
Battelle D[3]	03-2047-P	3.8		0.00	257.3				
Battelle D[3]	03-2048-P					1.8	96		
Battelle D[3]	03-2049-P							2.5	176
METSS RDF-2	03-2028-P[3]	3.3	3.2	0.00	214.4				
METSS RDF-2	03-2029-P[3]	3.1		0.00	206.8				
METSS RDF-2	03-2030-P					1.8	96		
METSS RDF-2	03-2031-P[3]							2.8	180
Clariant Safeway KF Hot	03-2019-P[3]	3.6	3.2	1.48	236.3				
Clariant Safeway KF Hot	03-2020-P[3]	2.5		0.00	163.6				
Clariant Safeway KF Hot	03-2022-P[3]	3.5		1.76	227.3				
Clariant Safeway KF Hot	03-2021-P					1.8	96		
AVIFORM L50	03-2010-P[3]	1.7	2.5	0.56	135.4				
AVIFORM L50	03-2011-P[3]	3.2		0.44	216.9				
AVIFORM L50	03-2013-P[3]	2.6		0.00	185.5				
AVIFORM L50	03-2012-P					1.8	96		

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
[3] The specimen was not homogeneous
Tests performed on 2003-10-06; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

SUMMARY
Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus
Polysulfide Sealant

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus			
						Tensile stress100% (MPa)	% El	Tensile stress300% (MPa)	% El
Unexposed	03-2108-P[3]	2.6		0.00	174.7				
Unexposed	03-2109-P	3.8	3.0	2.12	260.4				
Unexposed	03-2111-P[3]	2.6		0.00	172.7				
Unexposed	03-2110-P					1.8	96		
METSS ADF-2	03-2090-P	3.6		1.80	249.6				
METSS ADF-2	03-2091-P[3]	2.5	2.7	0.00	187.2				
METSS ADF-2	03-2093-P[3]	1.9		0.00	147.1				
METSS ADF-2	03-2092-P					1.7	96		
Battelle D[3]	03-2099-P[3]	3.3	3.4	0.96	226.3				
Battelle D[3]	03-2100-P	3.5		1.24	245.6				
Battelle D[3]	03-2101-P					1.7	98		
Battelle D[3]	03-2102-P							2.6	180
METSS RDF-2	03-2081-P	3.8	3.2	2.84	253.8				
METSS RDF-2	03-2082-P[3]	2.5		0.00	178.8				
METSS RDF-2	03-2083-P[3]					1.7	96		
METSS RDF-2	03-2084-P[3]							2.6	180
Clariant Safeway KF Hot	03-2072-P[3]	3.7	3.7	1.00	242.1				
Clariant Safeway KF Hot	03-2073-P	3.7		0.60	238.9				
Clariant Safeway KF Hot	03-2074-P					1.9	96		
Clariant Safeway KF Hot	03-2075-P							2.8	180
AVIFORM L50	03-2063-P[3]	3.3		0.68	205.4				
AVIFORM L50	03-2064-P	3.7	2.9	1.56	234.6				
AVIFORM L50	03-2067-P[3]	1.6		0.00	135.9				
AVIFORM L50	03-2065-P[3]					1.8	96		
AVIFORM L50	03-2066-P[3]							2.6	172

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
[3] The specimen was not homogeneous
Tests performed on 2003-10-06; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

SUMMARY
Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus Corrosion Inhibiting Sealant

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus: Tensile $stress_{100\%}$ (MPa)	Modulus: % El	Modulus: Tensile $stress_{300\%}$ (MPa)	Modulus: % El
Unexposed	03-2161-P[3]	2.0	1.4	5.80	274.7				
Unexposed	03-2162-P[3]	0.8		0.00	140.2				
Unexposed	03-2163-P[3]					0.8	92		
Unexposed	03-2164-P[3]							1.2	200
METSS ADF-2	03-2143-P	2.6	1.7	10.16	342.9				
METSS ADF-2	03-2144-P[3]	0.8		0.00	133.9				
METSS ADF-2	03-2145-P[3]					1.0	100		
METSS ADF-2	03-2146-P							1.5	204
Battelle D[3]	03-2152-P[3]	2.2	1.6	7.52	308.1				
Battelle D[3]	03-2153-P[3]	0.9		0.00	141.3				
Battelle D[3]	03-2154-P[3]					1.0	100		
Battelle D[3]	03-2155-P[3]							1.3	204
METSS RDF-2	03-2134-P	2.9	2.1	13.08	388.8				
METSS RDF-2	03-2135-P[3]	1.3		2.64	203.6				
METSS RDF-2	03-2136-P[3]					1.0	96		
METSS RDF-2	03-2137-P[3]							1.2	208
Clariant Safeway KF Hot	03-2125-P	2.9	2.6	13.76	390.2				
Clariant Safeway KF Hot	03-2126-P[3]	2.2		7.84	290.2				
Clariant Safeway KF Hot	03-2127-P[3]					0.9	100		
Clariant Safeway KF Hot	03-2128-P							1.4	204
AVIFORM L50	03-2116-P[3]	1.6	1.3	3.16	217.9				
AVIFORM L50	03-2117-P[3]	0.9		0.00	142.2				
AVIFORM L50	03-2118-P					1.0	100		
AVIFORM L50	03-2119-P[3]							1.3	208

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
[3] The specimen was not homogeneous
Tests performed on 2003-10-08; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

SUMMARY
Ultimate Tensile Strength and Percent elongation AS5127/1 paragraph 7.7 and 100% and 300% Modulus Polythioether Sealant

Deicer	Lab Sample ID	Ultimate tensile strength (MPa)	Average (Mpa)	% El[1] (without elasticity)	Distance[2] between grips at rupture (mm)	Modulus			
						Tensile stress$_{100\%}$ (MPa)	% El	Tensile stress$_{300\%}$ (MPa)	% El
Unexposed	03-2214-P[3]	1.9	1.3	0.96	167.11				
Unexposed	03-2215-P[3]	0.7		0.00	95.37				
Unexposed	03-2216-P					1.1	92		
Unexposed	03-2217-P[3]							2.7	176
METSS ADF-2	03-2196-P	3.5	2.6	5.40	238.02				
METSS ADF-2	03-2197-P[3]	2.6		0.00	186.41				
METSS ADF-2	03-2199-P[3]	1.8		0.00	150.64				
METSS ADF-2	03-2198-P					1.5	92		
Battelle D[3]	03-2205-P[3]	2.8	2.5	0.00	175.44				
Battelle D[3]	03-2206-P[3]	2.1		0.00	151.28				
Battelle D[3]	03-2207-P[3]					1.5	96		
Battelle D[3]	03-2208-P[3]							2.4	176
METSS RDF-2	03-2187-P	3.9	2.8	1.96	242.94				
METSS RDF-2	03-2188-P[3]	3.1		0.00	188.77				
METSS RDF-2	03-2190-P[3]	1.4		0.00	113.90				
METSS RDF-2	03-2189-P[3]					1.3	92		
Clariant Safeway KF Hot	03-2178-P[3]	2.0	1.7	0.00	139.74				
Clariant Safeway KF Hot	03-2179-P[3]	1.1		0.00	106.28				
Clariant Safeway KF Hot	03-2181-P[3]	1.6		0.00	119.54				
Clariant Safeway KF Hot	03-2182-P[3]	2.0		0.00	158.07				
Clariant Safeway KF Hot	03-2180-P[3]					2.0	94		
AVIFORM L50	03-2169-P[3]	1.7	1.4	0.00	120.58				
AVIFORM L50	03-2170-P[3]	1.6		0.00	167.74				
AVIFORM L50	03-2172-P[3]	0.9		0.00	130.64				
AVIFORM L50	03-2171-P					1.5	92		

[1] % Elongation: Relaxation time was 2 minutes
[2] Initial distance between grips was 80 mm
[3] The specimen was not homogeneous
Tests performed on 2003-10-09; Test conditions: relative humidity 40 ± 5% and temperature 22 ± 2°C
Detailed test results are presented in individual reports.

Appendix D
Aircraft Wire Test Results

Aircraft Wire Insulation

Immersion Test Results

Teflon

Deicer	Panel ID	Initial Diameter #1 (in)	Initial Diameter #2 (in)	Initial Diameter #3 (in)	Average Initial Diameter (in)	Midpoint Diameter #1 (in)	Midpoint Diameter #2 (in)	Midpoint Diameter #3 (in)	Average Midpoint Diameter (in)	Final Diameter #1 (in)	Final Diameter #2 (in)	Final Diameter #3 (in)	Average Final Diameter (in)	Swelled Diameter (in)	% Gain in Diameter	Standard Deviation	**Average Gain In Diameter (%)**
METSS ADF-2	03-1873-P	0.0579	0.0578	0.0576	0.0578	0.058	0.0576	0.058	0.0579	0.0583	0.0585	0.0586	0.0585	0.0007	1.2118	0.3386	**0.8**
	03-1874-P	0.058	0.0581	0.0578	0.0580	0.0582	0.0582	0.0578	0.0581	0.0584	0.0585	0.0582	0.0584	0.0004	0.6901		
	03-1875-P	0.0574	0.0579	0.058	0.0578	0.0581	0.0578	0.0581	0.0580	0.0578	0.0581	0.0584	0.0581	0.0003	0.5770		
Battelle D^3	03-1876-P	0.0581	0.0579	0.0579	0.0580	0.0583	0.0585	0.0581	0.0583	0.0577	0.0581	0.0583	0.0580	0.0001	0.1150	0.5216	**0.2**
	03-1877-P	0.0582	0.0581	0.0578	0.0580	0.0577	0.0577	0.058	0.0578	0.058	0.0577	0.0579	0.0579	-0.0002	-0.2872		
	03-1878-P	0.058	0.058	0.0579	0.0580	0.0577	0.0578	0.0583	0.0579	0.0584	0.0583	0.0585	0.0584	0.0004	0.7476		
METSS RDF-2	03-1870-P	0.0586	0.0586	0.0583	0.0585	0.0585	0.0581	0.058	0.0582	0.0578	0.0583	0.058	0.0580	-0.0005	-0.7977	1.0844	**0.0**
	03-1871-P	0.0574	0.0585	0.0583	0.0581	0.0582	0.0581	0.0586	0.0583	0.0578	0.0578	0.0575	0.0577	-0.0004	-0.6315		
	03-1872-P	0.0575	0.0577	0.0575	0.0576	0.0582	0.0584	0.0582	0.0583	0.058	0.0584	0.0583	0.0582	0.0007	1.1581		
Clariant Safeway KF Hot	03-1867-P	0.0587	0.0581	0.0582	0.0583	0.0578	0.0581	0.0584	0.0581	0.0583	0.0579	0.0587	0.0583	0.0000	-0.0571	0.3245	**0.0**
	03-1868-P	0.0581	0.0584	0.0587	0.0584	0.0573	0.0577	0.0575	0.0575	0.0578	0.0585	0.0577	0.0580	-0.0004	-0.6849		
	03-1869-P	0.0586	0.0582	0.0585	0.0584	0.058	0.0581	0.058	0.0580	0.0581	0.0581	0.0582	0.0581	-0.0003	-0.5134		
Hydro Chemicals AVIFORM L50	03-1864-P	0.0583	0.0579	0.0584	0.0582	0.0581	0.0583	0.058	0.0581	0.0582	0.0583	0.058	0.0582	0.0000	-0.0573	1.1784	**0.0**
	03-1865-P	0.0599	0.0582	0.0588	0.0590	0.058	0.0577	0.0581	0.0579	0.0577	0.0579	0.0582	0.0579	-0.0010	-1.7524		
	03-1866-P	0.0585	0.0586	0.0583	0.0585	0.0585	0.0587	0.0581	0.0584	0.0585	0.0589	0.0589	0.0588	0.0003	0.5131		

Hybrid Construction Wire

Deicer	Panel ID	Initial Diameter #1 (in)	Initial Diameter #2 (in)	Initial Diameter #3 (in)	Average Initial Diameter (in)	Midpoint Diameter #1 (in)	Midpoint Diameter #2 (in)	Midpoint Diameter #3 (in)	Average Midpoint Diameter (in)	Final Diameter #1 (in)	Final Diameter #2 (in)	Final Diameter #3 (in)	Average Final Diameter (in)	Swelled Diameter (in)	% Gain in Diameter	Standard Deviation	**Average Gain In Diameter (%)**
METSS ADF-2	03-1889-P	0.0518	0.0521	0.0516	0.0518	0.052	0.0515	0.0515	0.0517	0.0516	0.0518	0.0517	0.0517	-0.0001	-0.2572	0.2553	**0.0**
	03-1890-P	0.0522	0.0526	0.0526	0.0525	0.052	0.0522	0.0515	0.0519	0.0528	0.0516	0.0519	0.0521	-0.0004	-0.6989		
	03-1891-P	0.0519	0.0521	0.0521	0.0520	0.052	0.0524	0.0522	0.0522	0.0511	0.0524	0.0522	0.0519	-0.0001	-0.2562		
Battelle D^3	03-1892-P	0.052	0.0516	0.0525	0.0520	0.0521	0.0521	0.0531	0.0524	0.0522	0.0525	0.0523	0.0523	0.0003	0.5766	0.1330	**0.4**
	03-1893-P	0.0521	0.0517	0.052	0.0519	0.0525	0.0521	0.0521	0.0522	0.0521	0.0521	0.0521	0.0521	0.0002	0.3209		
	03-1894-P	0.0522	0.0515	0.0521	0.0519	0.0515	0.0516	0.0518	0.0516	0.0522	0.0521	0.0521	0.0521	0.0002	0.3851		
METSS RDF-2	03-1886-P	0.0501	0.0506	0.0511	0.0506	0.051	0.0512	0.0504	0.0509	0.0508	0.0505	0.0506	0.0506	0.0000	0.0659	0.6690	**0.6**
	03-1887-P	0.0515	0.0518	0.0517	0.0517	0.0526	0.0526	0.0525	0.0526	0.0516	0.0521	0.0519	0.0519	0.0002	0.3871		
	03-1888-P	0.0518	0.0525	0.0511	0.0518	0.0522	0.0517	0.0519	0.0519	0.0523	0.0526	0.0526	0.0525	0.0007	1.3514		
Clariant Safeway KF Hot	03-1883-P	0.0522	0.0526	0.0528	0.0525	0.053	0.0527	0.0526	0.0528	0.0523	0.0523	0.0525	0.0524	-0.0002	-0.3173	0.8802	**0.0**
	03-1884-P	0.0514	0.0517	0.0527	0.0519	0.0515	0.0517	0.0521	0.0518	0.0528	0.0523	0.052	0.0524	0.0004	0.8344		
	03-1885-P	0.0523	0.0523	0.0519	0.0522	0.0515	0.0515	0.0516	0.0515	0.0517	0.0515	0.0519	0.0517	-0.0005	-0.8946		
Hydro Chemicals AVIFORM L50	03-1880-P	0.053	0.0527	0.0526	0.0528	0.0522	0.053	0.0535	0.0529	0.0524	0.0523	0.0526	0.0524	-0.0003	-0.6317	0.7049	**0.0**
	03-1881-P	0.051	0.0511	0.0526	0.0516	0.051	0.0509	0.0508	0.0509	0.0515	0.051	0.0509	0.0511	-0.0004	-0.8403		
	03-1882-P	0.0534	0.0531	0.053	0.0532	0.0522	0.0522	0.0525	0.0523	0.0523	0.0521	0.052	0.0521	-0.0010	-1.9436		

Aircraft Wire Insulation

Immersion Test Results

Twisted Pair Wire

Deicer	Panel ID	Initial Diameter #1 (in)	Initial Diameter #2 (in)	Initial Diameter #3 (in)	Average Initial Diameter (in)	Midpoint Diameter #1 (in)	Midpoint Diameter #2 (in)	Midpoint Diameter #3 (in)	Average Midpoint Diameter (in)	Final Diameter #1 (in)	Final Diameter #2 (in)	Final Diameter #3 (in)	Average Final Diameter (in)	Swelled Diameter (in)	% Gain in Diameter	Standard Deviation	**Average Gain In Diameter (%)**
METSS ADF-2	03-1905-P	0.0824	0.0833	0.083	0.0829	0.0834	0.0831	0.0822	0.0829	0.0832	0.0828	0.0825	0.0828	-0.0001	-0.0804	0.1463	**0.1**
	03-1906-P	0.0819	0.0826	0.083	0.0825	0.0828	0.0831	0.0829	0.0829	0.0825	0.0826	0.0827	0.0826	0.0001	0.1212		
	03-1907-P	0.0824	0.0814	0.0813	0.0817	0.082	0.0813	0.0829	0.0821	0.0818	0.0814	0.0824	0.0819	0.0002	0.2040		
Battelle D^3	03-1908-P	0.0826	0.0833	0.0821	0.0827	0.0825	0.0829	0.0827	0.0827	0.0826	0.0835	0.0825	0.0829	0.0002	0.2419	0.2251	**0.3**
	03-1909-P	0.0814	0.0819	0.0816	0.0816	0.0817	0.0824	0.0825	0.0822	0.0813	0.0823	0.0825	0.0820	0.0004	0.4900		
	03-1910-P	0.0828	0.0822	0.0818	0.0823	0.0822	0.0831	0.0832	0.0828	0.0819	0.0816	0.0834	0.0823	0.0000	0.0405		
METSS RDF-2	03-1902-P	0.0818	0.0808	0.0822	0.0816	0.0834	0.082	0.0817	0.0824	0.0831	0.0818	0.0817	0.0822	0.0006	0.7353	0.6127	**0.7**
	03-1903-P	0.082	0.0816	0.082	0.0819	0.0822	0.0826	0.0823	0.0824	0.0817	0.0817	0.0822	0.0819	0.0000	0.0000		
	03-1904-P	0.082	0.0828	0.0818	0.0822	0.0838	0.0832	0.0826	0.0832	0.0834	0.0833	0.0829	0.0832	0.0010	1.2165		
Clariant Safeway KF Hot	03-1899-P	0.0825	0.0816	0.0819	0.0820	0.0816	0.0827	0.0824	0.0822	0.0826	0.082	0.0823	0.0823	0.0003	0.3659	0.3040	**0.7**
	03-1900-P	0.0826	0.0826	0.0814	0.0822	0.0829	0.0835	0.0834	0.0833	0.0834	0.083	0.0826	0.0830	0.0008	0.9732		
	03-1901-P	0.0823	0.0825	0.0824	0.0824	0.0826	0.0826	0.0831	0.0828	0.083	0.0828	0.083	0.0829	0.0005	0.6472		
Hydro Chemicals AVIFORM L50	03-1896-P	0.083	0.083	0.0833	0.0831	0.0831	0.083	0.0833	0.0831	0.0831	0.0841	0.084	0.0837	0.0006	0.7621	0.4685	**0.3**
	03-1897-P	0.0831	0.0834	0.0833	0.0833	0.0836	0.0835	0.0832	0.0834	0.0834	0.0835	0.0833	0.0834	0.0001	0.1601		
	03-1898-P	0.083	0.0831	0.0829	0.0830	0.0833	0.0831	0.083	0.0831	0.0826	0.083	0.083	0.0829	-0.0001	-0.1606		

Polyimide Wire

Deicer	Panel ID	Initial Diameter #1 (in)	Initial Diameter #2 (in)	Initial Diameter #3 (in)	Average Initial Diameter (in)	Midpoint Diameter #1 (in)	Midpoint Diameter #2 (in)	Midpoint Diameter #3 (in)	Average Midpoint Diameter (in)	Final Diameter #1 (in)	Final Diameter #2 (in)	Final Diameter #3 (in)	Average Final Diameter (in)	Swelled Diameter (in)	% Gain in Diameter	Standard Deviation	**Average Gain In Diameter (%)**
METSS ADF-2	03-1921-P	0.0557	0.0554	0.0557	0.0556	0.0552	0.0556	0.0559	0.0556	0.0554	0.0559	0.0558	0.0557	0.0001	0.1799	0.3306	**0.5**
	03-1922-P	0.0556	0.0565	0.056	0.0560	0.0558	0.0564	0.056	0.0561	0.0565	0.0563	0.0567	0.0565	0.0005	0.8328		
	03-1923-P	0.0553	0.0558	0.0566	0.0559	0.0564	0.0566	0.0561	0.0564	0.0559	0.056	0.0568	0.0562	0.0003	0.5963		
Battelle D^3	03-1924-P	0.0559	0.0555	0.0559	0.0558	0.0558	0.0559	0.0564	0.0560	0.0561	0.0562	0.0559	0.0561	0.0003	0.5380	0.2773	**0.8**
	03-1925-P	0.0555	0.0557	0.0561	0.0558	0.0556	0.0564	0.0561	0.0560	0.0563	0.0562	0.0563	0.0563	0.0005	0.8966		
	03-1926-P	0.0556	0.055	0.0555	0.0554	0.0555	0.0556	0.0559	0.0557	0.0556	0.0561	0.0562	0.0560	0.0006	1.0837		
METSS RDF-2	03-1918-P	0.0556	0.0563	0.0562	0.0560	0.0564	0.0567	0.0565	0.0565	0.056	0.0559	0.0569	0.0563	0.0002	0.4164	0.5649	**0.2**
	03-1919-P	0.0556	0.0556	0.056	0.0557	0.0566	0.056	0.0558	0.0561	0.0563	0.0558	0.0562	0.0561	0.0004	0.6579		
	03-1920-P	0.056	0.0559	0.0553	0.0557	0.0552	0.0553	0.0554	0.0553	0.0556	0.0554	0.0555	0.0555	-0.0002	-0.4187		
Clariant Safeway KF Hot	03-1915-P	0.0559	0.0554	0.0556	0.0556	0.0553	0.0553	0.0557	0.0554	0.0562	0.0557	0.056	0.0560	0.0003	0.5992	0.3509	**0.2**
	03-1916-P	0.0562	0.0562	0.0563	0.0562	0.0562	0.0561	0.0563	0.0562	0.0558	0.0563	0.0567	0.0563	0.0000	0.0593		
	03-1917-P	0.0565	0.0564	0.0564	0.0564	0.0558	0.0564	0.0562	0.0561	0.0558	0.0568	0.0566	0.0564	0.0000	-0.0591		
Hydro Chemicals AVIFORM L50	03-1912-P	0.0562	0.0562	0.0561	0.0562	0.0558	0.0562	0.0563	0.0561	0.056	0.0563	0.0564	0.0562	0.0001	0.1187	0.4056	**0.6**
	03-1913-P	0.0562	0.0555	0.056	0.0559	0.0553	0.0555	0.0555	0.0554	0.0565	0.0563	0.0561	0.0563	0.0004	0.7156		
	03-1914-P	0.0563	0.0558	0.0559	0.0560	0.0561	0.0564	0.0563	0.0563	0.0565	0.0563	0.0567	0.0565	0.0005	0.8929		

Aircraft Wire Insulation

Bend Test – Post Immersion

Teflon

Deicer	Lab Sample ID	Test Results and Comments
Unexposed	03-1879-P	No Effect
METSS ADF-2	03-1873-P	No Effect
	03-1874-P	No Effect
	03-1875-P	No Effect
Battelle D(3)	03-1876-P	No Effect
	03-1877-P	No Effect
	03-1878-P	No Effect
METSS RDF-2	03-1870-P	No Effect
	03-1871-P	No Effect
	03-1872-P	No Effect
Safeway KF Hot	03-1867-P	No Effect
	03-1868-P	No Effect
	03-1869-P	No Effect
AVIFORM L50	03-1864-P	No Effect
	03-1865-P	No Effect
	03-1866-P	No Effect

Hybrid Construction

Deicer	Lab Sample ID	Test Results and Comments
Unexposed	03-1895-P	No Effect
METSS ADF-2	03-1889-P	No Effect
	03-1890-P	No Effect
	03-1891-P	No Effect
Battelle D(3)	03-1892-P	No Effect
	03-1893-P	No Effect
	03-1894-P	No Effect
METSS RDF-2	03-1886-P	No Effect
	03-1887-P	No Effect
	03-1888-P	No Effect
Safeway KF Hot	03-1883-P	No Effect
	03-1884-P	No Effect
	03-1885-P	No Effect
AVIFORM L50	03-1880-P	No Effect
	03-1881-P	No Effect
	03-1882-P	No Effect

Aircraft Wire Insulation

Bend Test – Post Immersion

Cable-Insulated Twisted Wire

Deicer	Lab Sample ID	Test Results and Comments
Unexposed	03-1911-P	Wires started to unravel (untwist)
METSS ADF-2	03-1905-P	No Effect
	03-1906-P	Thinning occurred at top of wire, outside of immersion area
	03-1907-P	No Effect
Battelle D(3)	03-1908-P	No Effect
	03-1909-P	No Effect
	03-1910-P	No Effect
METSS RDF-2	03-1902-P	No Effect
	03-1903-P	No Effect
	03-1904-P	No Effect
Safeway KF Hot	03-1899-P	No Effect
	03-1900-P	No Effect
	03-1901-P	No Effect
AVIFORM L50	03-1896-P	No Effect
	03-1897-P	No Effect
	03-1898-P	No Effect

Polyamide

Deicer	Lab Sample ID	Test Results and Comments
Unexposed	03-1927-P	No Effect
METSS ADF-2	03-1921-P	No Effect
	03-1922-P	No Effect
	03-1923-P	No Effect
Battelle D(3)	03-1924-P	No Effect
	03-1925-P	No Effect
	03-1926-P	No Effect
METSS RDF-2	03-1918-P	No Effect
	03-1919-P	No Effect
	03-1920-P	No Effect
Safeway KF Hot	03-1915-P	No Effect
	03-1916-P	No Effect
	03-1917-P	No Effect
AVIFORM L50	03-1912-P	No Effect
	03-1913-P	No Effect
	03-1913-P	No Effect

Aircraft Wire Insulation

Voltage Withstand Test

Teflon

Deicer	Lab Sample ID	Current	Pass/Fail	Comments
Unexposed	03-1879-P	0.15	Pass	
METSS ADF-2	03-1873-P	0.14	Pass	
	03-1874-P	0.15	Pass	
	03-1875-P	0.15	Pass	
Battelle D(3)	03-1876-P	0.15	Pass	
	03-1877-P	0.15	Pass	
	03-1878-P	0.15	Pass	
METSS RDF-2	03-1870-P	0.15	Pass	
	03-1871-P	0.15	Pass	
	03-1872-P	0.15	Pass	
Safeway KF Hot	03-1867-P	0.15	Pass	
	03-1868-P	0.15	Pass	
	03-1869-P	0.15	Pass	
AVIFORM L50	03-1864-P	0.15	Pass	
	03-1865-P	0.15	Pass	
	03-1866-P	0.15	Pass	

Hybrid Construction

Deicer	Lab Sample ID	Current (mA)	Pass/Fail	Comments
Unexposed	03-1895-P	0.19	Pass	
METSS ADF-2	03-1889-P	0.20	Pass	
	03-1890-P	0.19	Pass	
	03-1891-P	0.20	Pass	
Battelle D(3)	03-1892-P	0.20	Pass	
	03-1893-P	0.20	Pass	
	03-1894-P	0.20	Pass	
METSS RDF-2	03-1886-P	0.21	Pass	
	03-1887-P	0.20	Pass	
	03-1888-P	0.20	Pass	
Safeway KF Hot	03-1883-P	0.19	Pass	
	03-1884-P	0.19	Pass	
	03-1885-P	0.20	Pass	
AVIFORM L50	03-1880-P	0.19	Pass	
	03-1881-P	0.21	Pass	
	03-1882-P	0.20	Pass	

Raytheon

Technical Services Company
Engineering and Production Support
6125 East 21st Street
Indianapolis, Indiana
46219-2058 USA
317.306.8471

29 September 2003

Refer To: 03/CNEA50/KWC37/3130

Concurrent Technologies Corporation
Attn: Susan Van Scoyoc
Staff Chemical Engineer
100 CTC Drive
Johnstown, PA 15904 USA

Mrs. Van Scoyoc,

Raytheon Technical Services Company (RTSC) was contracted by Concurrent Technologies Corporation to conduct Wet Arc Track Resistance Testing of Runway Deicing Fluids on Mil-W-81381/11-20 polyimide insulated wire in accordance with Raytheon letter 03-20574-08JM/3ATLC001-15 of 26 February 2003.

Raytheon Technical Services Company, Indianapolis, Indiana, performed wet arc track resistance testing. Bundles of Mil-W-81381/11-20 polyimide insulated wire were tested per MIL-STD-2223, Method 3006, substituting five different runway deicing solutions for the salt water exposure solution in order to evaluate their relative resistance to forming wet arc tracks. Each deicing fluid was applied at a rate of 100 mg ± 10 mg per minute to each of three wire bundles. The equipment used to perform this test is a Lectromec Wet and Dry Arc Track Resistance Test System, Model 113094-01 using the wet arc track test module. All tests were performed with the test system resistance set to 2.0 ohms. Four reference tests were performed as follows: three tests using a 3% solution of NaCl by weight in deionized water, and one test using only deionized water. The test data results are provided in enclosure 1.

Test Results Summary:

Deicing fluids, Aviform L50 and METSS RDF-2, demonstrated arc track generation characteristics and subsequent arcing events, on the average, slightly faster, but essentially commensurate with that of the reference 3% NaCl solution. Safeway KF runway deicer exhibited, on the average, a 46% delay in time to a catastrophic arcing event over the 3% NaCl reference solution. All test bundles, except one, with these three deicing fluids resulted in extensive collateral damage causing all adjacent wires to fail the Dielectric Withstanding Voltage (DWV) test. The one test bundle from the Safeway KF test group had one wire (D2 a non-powered wire) which passed the DWV test following wet arc tracking. Additionally, the Safeway KF material is the only fluid which had circuit breaker trips prior to a test ending event. Overall, when power was reapplied to these single circuit breaker faults, the subsequent arcing event damage was roughly equivalent to that of the 3% NaCl fluid and the other two deicing fluids.

Battelle's D^3 runway deicer did not experience a catastrophic arcing event, but was observed to produce small, localized arcs within the exposed conductor areas of the A1-B1 wires. The Battelle D^3 runway deicing fluid appeared to be vaporizing or boiling off of the cable due to current induced heating of the fluid, as it allowed an electrical current to flow between the adjacent exposed wires. This is a common reaction to this test with most electrically conductive

fluids. Although this fluid exhibited conductive characteristics, a catastrophic arcing event did not materialize and each test using it ran the entire 8-hour test period. The Battelle D^3 material did, however, change the appearance of the exposed, silver-coated copper wire to a bluish-black color.

The METSS ADF-2 runway deicing fluid did not react with or discolor the exposed wire, nor did it boil or vaporize upon application and it completed each 8-hour test interval without any arcing events. This fluid exhibited performance characteristics comparable to that of deionized water in this test.

CAUTION: The data presented in this report is based upon a limited volume of testing and should only be used to form relative and generalized qualitative performance evaluations of the products tested under the stated test conditions.

Test results of supplied deicing fluids can be separated into three groups:

The first group of deicing fluids is comprised of Aviform L50, METSS RDF-2 and Safeway KF. These deicing fluids generated wet arc tracking events nearly identical in time, number of wires damaged and length of damaged wire as compared to those events induced by the standard 3% NaCl in deionized water solution.

In the second group is the Battelle D^3 deicing fluid, which exhibited electrically conductive characteristics and discolored the exposed wiring, but did not precipitate a catastrophic arcing event during these tests.

METSS ADF-2 runway deicing fluid is in the third group. This deicing fluid showed no reaction with the wire or insulation during each test.

Any questions about the results and tests should be directed to Mr. Kenneth Croy, (317) 306-7267.

Please be advised that we are returning the remainder of the deicing fluids under a separate cover to your attention.

Sincerely Yours,

Larry Clines
Project Manager, Aircraft Wiring

Encl: (1) Raytheon Technical Services Company Project 50-01-180, Test Data for Concurrent Technologies Corporation, Runway Deicing Fluid Wet Arc Tracking Resistance Testing.
Encl: (2) Test cables

Raytheon Technical Services Company, Indianapolis, Indiana

TEST PROCEDURE #3006-CTC
Wet Arc-Track Propagation w/ Wet DWV

DATE (last revised): 6/19/03

Conducted by: Andrew Brown **Date started:** 09/02/03 **Project #** 50-01-180

Manufacturer: Thermax **Wire Type/Sheet:** MI-W-81381/11-20 (normal / thin)

Lectromec Wet and Dry Arc Track Propagation Test System, model 113094-01, with the Wet Test Module

Arc-Propagation Results/ (Post) Wet Dielectric Results

Test # /date	Deicing Fluid Tested	Event # / Result * indicates halted prior to 8 hours	## ___seconds	Resist (Ohms)	Maximum damaged wire length in inches	Excluding A1 - B1	
						ID of wires passing DWV	ID of Failed wires
#1 / 09/03/03	AVIFORM L50	1 / B1& C1 Tripped *	1 / 82.4	2	2.9	None	ALL
#2 / 09/03/03	AVIFORM L50	1 / B1& C1 Tripped *	1 / 14.3	2	1.7	None	ALL
#3 / 09/03/03	AVIFORM L50	1 / B1& C1 Tripped *	1 / 8.0	2	1.7	None	ALL
#4 / 09/04/03	METSS RDF-2	1 / B1& C1 Tripped *	1 / 42.8	2	2.4	None	ALL
#5 / 09/04/03	METSS RDF-2	1 / B1& C1 Tripped *	1 / 19.2	2	1.4	None	ALL
#6 / 09/04/03	METSS RDF-2	1 / B1, B2 & C1 Tripped *	1 / 28.5	2	2.8	None	ALL
#7 / 09/05/03	SAFEWAY KF	1 / B1 Tripped 3 Minute Wait to Re-powering 2 / B1 & C1 Tripped*	1 / 50.6 2 / 51.8	2	2.5	D2	A2, B2, C1, D1
#8 / 09/05/03	SAFEWAY KF	1 / B1 Tripped 3 Minute Wait to Re-powering 2 / B1 & C1 Tripped*	1 / 37.4 2 / 38.1	2	3.0	None	ALL
#9 / 09/05/03	SAFEWAY KF	1 / B1& C1 Tripped *	1 / 58.1	2	1.8	None	ALL
#10 / 09/08/03	METSS ADF-2	No Event	28,800	2	N/A	ALL	None
#11 / 09/09/03	METSS ADF-2	No Event	28,800	2	N/A	ALL	None
#12 / 09/10/03	METSS ADF-2	No Event	28,800	2	N/A	ALL	None
#13 / 09/15/03	Battelle D³	No Event	28,800	2	N/A	ALL	None
#14 / 09/16/03	Battelle D³	No Event	28,800	2	N/A	ALL	None
#15 / 09/17/03	Battelle D³	No Event	28,800	2	N/A	ALL	None
#16 / 09/11/03	3% NaCl by wt. in D.I. Water	1 / A1, B1& C1 Tripped *	1 / 28.4	2	2.8	None	ALL
#17 / 09/11/03	3% NaCl by wt. in D.I. Water	1 / B1& C1 Tripped *	1 / 38.4	2	1.9	None	ALL
#18 / 09/11/03	3% NaCl by wt. in D.I. Water	1 / A1& C1 Tripped *	1 / 35.3	2	2.9	None	ALL
#19 / 09/02/03	Deionized Water	No Event	28,800	2	N/A	ALL	None

Encl. 1

Page 1 of 2

Comments, Notes & Observations:

1. Tests # 7 & 8 of the cable bundles using Safeway KF fluid experienced their initial circuit breaker trips in the B1 circuit breaker only. Per the test specification, this condition requires a waiting period of 3 minutes (180 Seconds) after which the tripped circuit breaker is reset and power re-applied to the cable bundle under test. During this waiting period the fluid tested is allowed to continue dripping on the cable bundle. Both cable bundles that experienced this type of event proceeded to initiate arcing within 2 seconds of re-powering, which re-tripped the B1 circuit breaker along with Circuit Breaker C1. The second tripping event of B1 and/or first time tripping of C1 are cause for termination of testing on that cable bundle. Test time is considered to be the total accumulated cable energized time until a test terminating failure, if any, occurs.
2. Tests # 13, 14 &15: Battelle D^3 Fluid boiled and vaporized upon application. Small sparks visible on exposed wire of A1 & B1. Fluid discolored the exposed silver-coated copper wire during the testing leaving it a bluish-black in appearance.

Appendix E
Carbon-Carbon Brake Materials

Carbon-Carbon Brake Friction Materials

Cyclic Heating Test

Carbenix 1000		Initial		1st Exposer		1st Heating Cycle		Final Heating Cycle					
Deicer	Lab Sample ID	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	**Average Weight Loss (%)**	**Average Hardness Loss (%)**
DI Water	03-2498-P	23.0444	92	23.0493	85	20.1046	54	11.5871	5	49.7	94.6	**47.2**	**84.8**
DI Water	03-2499-P	23.0157	89	23.0195	84	20.6864	62	13.2527	22	42.4	75.3		
DI Water	03-2500-P	23.2756	90	23.2796	89	19.6965	53	11.4347	14	50.9	84.4		
DI Water	03-2501-P	22.9740	93	22.9789	78	19.1748	51	12.4711	14	45.7	84.9		
METSS ADF-2	03-2490-P	22.9855	89	23.2451	82	18.0383	58	10.9848	20	52.2	77.5	**53.4**	**67.6**
METSS ADF-2	03-2491-P	22.9270	92	23.1969	85	19.8887	62	13.5539	23	40.9	75.0		
METSS ADF-2	03-2492-P	23.0000	90	23.2589	85	18.6225	48	11.4657	28	50.1	68.9		
METSS ADF-2	03-2493-P	22.9725	88	23.2315	87	18.9972	51	6.7856	45	70.5	48.9		
Battelle D(3)	03-2494-P	22.9066	88	23.0809	84	17.0520	49	7.0391	38	69.3	56.8	**62.2**	**56.8**
Battelle D(3)	03-2495-P	22.8172	91	23.0272	78	16.4351	58	8.6393	28	62.1	69.2		
Battelle D(3)	03-2496-P	22.7736	89	22.9932	85	17.4071	65	10.2963	42	54.8	52.8		
Battelle D(3)	03-2497-P	23.0713	91	23.2156	84	19.3988	48	8.6604	47	62.5	48.4		
METSS RDF-2	03-2486-P	22.6911	90	23.0421	87	15.7959	84	9.1858	78	59.5	13.3	**56.9**	**13.0**
METSS RDF-2	03-2487-P	22.6722	90	23.0306	86	16.2624	76	9.9274	80	56.2	11.1		
METSS RDF-2	03-2488-P	22.6499	90	22.9827	88	17.1410	81	9.7412	75	57.0	16.7		
METSS RDF-2	03-2489-P	23.0965	91	23.4171	92	16.2201	73	10.4419	81	54.8	11.0		
Safeway KF Hot	03-2482-P	23.0833	90	23.2804	83	16.1375	83	9.0130	85	61.0	5.6	**65.7**	**11.4**
Safeway KF Hot	03-2483-P	23.0234	90	23.2451	83	14.5527	77	8.7786	76	61.9	15.6		
Safeway KF Hot	03-2484-P	23.0132	89	23.3859	81	15.4725	72	9.0375	78	60.7	12.4		
Safeway KF Hot	03-2485-P	22.8936	91	23.0865	84	10.8379	81	4.7641	80	79.2	12.1		
Aviform L50	03-2478-P	22.9095	91	23.0412	87	16.7943	79	10.9361	82	52.3	9.9	**51.8**	**10.8**
Aviform L50	03-2479-P	22.8024	89	23.0008	84	15.3445	71	9.8450	81	56.8	9.0		
Aviform L50	03-2480-P	23.0167	90	23.2317	89	23.0548	85	14.0898	79	38.8	12.2		
Aviform L50	03-2481-P	22.8196	92	23.0428	89	16.0195	78	9.2360	81	59.5	12.0		

Carbon-Carbon Brake Friction Materials
Cyclic Heating Test

Carbenix 1000 + antiox ctg

Deicer	Lab Sample ID	Initial Weight (gm)	Initial Hardness Type D Durameter	1st Exposer Weight (gm)	1st Exposer Hardness Type D Durameter	1st Heating Cycle Weight (gm)	1st Heating Cycle Hardness Type D Durameter	Final Heating Cycle Weight (gm)	Final Heating Cycle Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2522-P	23.1877	87	23.1608	83	22.7673	85	21.8731	77	5.7	11.5	5.3	10.8
DI Water	03-2523-P	22.7854	90	22.7706	90	22.2937	86	21.5879	82	5.3	8.9		
DI Water	03-2524-P	23.3323	89	23.2944	85	22.9508	87	22.1664	79	5.0	11.2		
DI Water	03-2525-P	23.2045	85	23.1699	88	22.8222	86	21.9760	75	5.3	11.8		
METSS ADF-2	03-2514-P	23.3722	86	23.5015	87	22.8478	84	21.7774	75	6.8	12.8	6.2	15.5
METSS ADF-2	03-2515-P	23.3324	86	23.4607	87	22.8791	86	21.9864	76	5.8	11.6		
METSS ADF-2	03-2516-P	23.2380	83	23.4073	83	22.7418	83	21.7129	76	6.6	8.4		
METSS ADF-2	03-2517-P	23.3240	93	23.4542	85	22.8308	83	22.0181	66	5.6	29.0		
Battelle D(3)	03-2518-P	23.1169	87	23.2060	86	22.6292	87	21.7320	66	6.0	24.1	4.9	15.8
Battelle D(3)	03-2519-P	23.4861	89	23.4992	86	23.1024	85	22.4134	81	4.6	9.0		
Battelle D(3)	03-2520-P	23.1835	86	23.2406	86	22.7540	84	22.1741	80	4.4	7.0		
Battelle D(3)	03-2521-P	23.1812	87	23.2098	84	22.7544	83	22.0982	67	4.7	23.0		
METSS RDF-2	03-2510-P	23.1383	90	23.4420	91	18.1407	69	11.9295	53	48.4	41.1	36.0	49.2
METSS RDF-2	03-2511-P	23.0419	89	23.3625	86	17.9112	54	13.4767	47	41.5	47.2		
METSS RDF-2	03-2512-P	23.3171	90	23.4567	89	20.5055	78	17.4098	38	25.3	57.8		
METSS RDF-2	03-2513-P	23.3929	89	23.5355	91	19.9312	72	16.6562	44	28.8	50.6		
Safeway KF Hot	03-2506-P	23.1148	85	23.2483	85	20.6161	58	18.3420	46	20.6	45.9	27.7	43.3
Safeway KF Hot	03-2507-P	23.4726	90	23.5418	87	18.7525	66	15.4063	56	34.4	37.8		
Safeway KF Hot	03-2508-P	23.4372	89	23.4977	84	20.1870	60	17.4709	36	25.5	59.6		
Safeway KF Hot	03-2509-P	23.4736	87	23.5499	88	19.1025	79	16.3328	61	30.4	29.9		
Aviform L50	03-2502-P	23.3529	88	23.4125	89	23.2197	89	21.3205	68	8.7	22.7	14.6	33.9
Aviform L50	03-2503-P	23.1677	90	23.2383	87	23.0965	96	19.3989	57	16.3	36.7		
Aviform L50	03-2504-P	23.1038	87	23.1958	88	22.9717	90	19.5486	43	15.4	50.6		
Aviform L50	03-2505-P	23.2899	90	23.3726	87	23.2089	89	19.0822	67	18.1	25.6		

Carbon-Carbon Brake Friction Materials
Cyclic Heating Test

Carbenix 2000

Deicer	Lab Sample ID	Initial Weight (gm)	Initial Hardness Type D Durameter	1st Exposer Weight (gm)	1st Exposer Hardness Type D Durameter	1st Heating Cycle Weight (gm)	1st Heating Cycle Hardness Type D Durameter	Final Heating Cycle Weight (gm)	Final Heating Cycle Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2546-P	21.5391	92	21.5422	88	17.8783	58	11.4084	12	47.0	87.0	45.0	82.7
DI Water	03-2547-P	22.0319	95	22.0350	91	18.6917	68	11.8537	19	46.2	80.0		
DI Water	03-2548-P	21.6690	87	21.6726	89	18.6804	53	12.1564	13	43.9	85.1		
DI Water	03-2549-P	21.8128	89	21.8169	87	118.7153	49	12.4856	19	42.8	78.7		
METSS ADF-2	03-2538-P	21.9518	90	21.7920	87	17.4775	50	10.2490	15	53.3	83.3	48.3	84.5
METSS ADF-2	03-2539-P	21.8544	91	22.0143	87	17.9937	44	11.9437	13	45.3	85.7		
METSS ADF-2	03-2540-P	21.7611	92	21.7535	85	18.5561	58	12.2062	18	43.9	80.4		
METSS ADF-2	03-2541-P	21.6625	96	22.0225	84	18.6640	56	10.6945	11	50.6	88.5		
Battelle D(3)	03-2542-P	22.0265	91	22.1512	86	19.4099	74	14.9620	56	32.1	38.5	39.3	51.1
Battelle D(3)	03-2543-P	21.6406	90	21.7597	85	19.1106	61	14.5275	40	32.9	55.6		
Battelle D(3)	03-2544-P	21.8344	90	21.9453	85	18.4616	74	12.0485	50	44.8	44.4		
Battelle D(3)	03-2545-P	22.0402	91	22.1680	87	18.1311	72	11.5936	31	47.4	65.9		
METSS RDF-2	03-2534-P	21.8765	91	22.0691	91	16.6996	78	10.5668	72	51.7	20.9	55.2	11.9
METSS RDF-2	03-2535-P	21.6297	90	21.8879	82	15.1528	81	9.3362	84	56.8	6.7		
METSS RDF-2	03-2536-P	21.8628	90	22.0586	87	15.3559	82	9.9170	82	54.6	8.9		
METSS RDF-2	03-2537-P	22.0500	90	22.2543	93	16.7093	74	9.3142	80	57.8	11.1		
Safeway KF Hot	03-2530-P	21.9031	93	21.9677	88	14.6007	58	12.4102	68	43.3	26.9	56.9	25.2
Safeway KF Hot	03-2531-P	21.7978	95	21.8423	89	15.5068	76	6.6838	64	69.3	32.6		
Safeway KF Hot	03-2532-P	21.9964	89	22.0505	89	13.6008	74	8.6386	77	60.7	13.5		
Safeway KF Hot	03-2533-P	21.7201	93	21.7743	88	15.1923	82	9.9572	67	54.2	28.0		
Aviform L50	03-2526-P	21.9029	91	21.9296	88	16.5778	77	11.8943	63	45.7	30.8	45.6	32.7
Aviform L50	03-2527-P	21.7702	90	21.7975	90	16.5744	80	12.3355	70	43.3	22.2		
Aviform L50	03-2528-P	21.6055	90	21.6318	90	21.5033	88	15.6204	68	27.7	24.4		
Aviform L50	03-2529-P	21.7223	90	21.7511	87	10.9398	82	7.4541	42	65.7	53.3		

Carbon-Carbon Brake Friction Materials

Cyclic Heating Test

Carbenix 2000 + antiox ctg

Deicer	Lab Sample ID	Initial Weight (gm)	Initial Hardness Type D Durameter	1st Exposer Weight (gm)	1st Exposer Hardness Type D Durameter	1st Heating Cycle Weight (gm)	1st Heating Cycle Hardness Type D Durameter	Final Heating Cycle Weight (gm)	Final Heating Cycle Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2570-P	22.0485	87	22.0800	86	21.4249	82	19.7944	61	10.2	29.9	10.5	32.3
DI Water	03-2571-P	22.1996	88	22.2436	85	21.4992	73	19.8372	53	10.6	39.8		
DI Water	03-2572-P	21.9605	86	22.0028	84	21.1842	67	19.4912	52	11.2	39.5		
DI Water	03-2573-P	21.8658	95	21.9198	88	21.1714	89	19.6609	76	10.1	20.0		
METSS ADF-2	03-2562-P	22.0829	87	22.2867	87	21.4693	70	19.3439	58	12.4	33.3	11.7	29.1
METSS ADF-2	03-2563-P	22.1060	89	22.3095	87	21.3554	89	19.4883	79	11.8	11.2		
METSS ADF-2	03-2564-P	21.9541	83	22.1477	81	21.2108	74	19.2356	54	12.4	34.9		
METSS ADF-2	03-2565-P	21.8188	87	22.0212	83	21.1883	72	19.6339	55	10.0	36.8		
Battelle D(3)	03-2566-P	22.2483	88	22.3724	83	21.5777	75	20.3547	64	8.5	27.3	10.3	36.4
Battelle D(3)	03-2567-P	21.9170	93	22.0195	86	21.2066	77	19.8408	62	9.5	33.3		
Battelle D(3)	03-2568-P	21.9939	91	22.1398	85	21.1951	74	19.4575	51	11.5	44.0		
Battelle D(3)	03-2569-P	22.1596	85	22.2565	88	21.3406	74	19.6058	50	11.5	41.2		
METSS RDF-2	03-2558-P	22.0360	88	22.2536	89	18.7628	41	8.7054	40	60.5	54.5	48.7	57.4
METSS RDF-2	03-2559-P	21.9700	88	22.1366	88	18.3713	49	13.0545	40	40.6	54.5		
METSS RDF-2	03-2560-P	22.0926	87	22.2775	88	17.0682	63	10.8885	34	50.7	60.9		
METSS RDF-2	03-2561-P	22.2004	92	22.4296	93	18.1019	81	12.6823	37	42.9	59.8		
Safeway KF Hot	03-2554-P	21.9242	86	22.1461	86	16.9289	44	9.4664	11	56.8	87.2	54.1	64.8
Safeway KF Hot	03-2555-P	22.0163	85	22.1723	91	13.4559	35	6.3539	46	71.1	45.9		
Safeway KF Hot	03-2556-P	22.0820	88	22.2190	87	17.5731	61	12.1395	30	45.0	65.9		
Safeway KF Hot	03-2557-P	22.1999	88	22.3498	85	18.3670	58	12.5338	35	43.5	60.2		
Aviform L50	03-2550-P	21.8890	88	22.0469	87	21.8533	86	11.9592	65	45.4	26.1	35.5	33.2
Aviform L50	03-2551-P	21.6670	90	21.9176	89	21.6763	89	13.9611	48	35.6	46.7		
Aviform L50	03-2552-P	21.8511	87	22.1672	91	21.7484	86	15.1684	52	30.6	40.2		
Aviform L50	03-2553-P	22.0963	86	22.3533	87	21.9626	85	15.3661	69	30.5	19.8		

Carbon-Carbon Brake Friction Materials

Cyclic Heating Test

Carbenix 2110

Deicer	Lab Sample ID	Initial Weight (gm)	Initial Hardness Type D Durameter	1st Exposer Weight (gm)	1st Exposer Hardness Type D Durameter	1st Heating Cycle Weight (gm)	1st Heating Cycle Hardness Type D Durameter	Final Heating Cycle Weight (gm)	Final Heating Cycle Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2594-P	25.1833	83	25.1988	83	24.5246	71	23.1771	74	8.0	10.8	12.8	32.1
DI Water	03-2595-P	25.2605	82	25.3018	80	24.2980	67	22.4110	54	11.3	34.1		
DI Water	03-2596-P	25.0331	85	25.0401	81	22.8271	65	19.2916	41	22.9	51.8		
DI Water	03-2597-P	25.3514	85	25.3821	78	24.6199	73	23.0202	58	9.2	31.8		
METSS ADF-2	03-2586-P	25.2290	79	25.7552	77	22.8824	60	16.6186	30	34.1	62.0	35.1	65.7
METSS ADF-2	03-2587-P	24.9993	81	25.5256	77	21.2863	53	11.9499	12	52.2	85.2		
METSS ADF-2	03-2588-P	25.1677	83	25.6924	80	21.8927	54	17.2007	33	31.7	60.2		
METSS ADF-2	03-2589-P	25.2885	76	25.8109	79	22.9712	58	19.5950	34	22.5	55.3		
Battelle D(3)	03-2590-P	25.0642	87	25.8216	76	21.4494	51	16.3568	24	34.7	72.4	20.3	51.9
Battelle D(3)	03-2591-P	25.3395	82	26.1448	80	24.0466	70	21.5781	53	14.8	35.4		
Battelle D(3)	03-2592-P	25.2265	85	25.9931	77	23.9225	61	21.4870	41	14.8	51.8		
Battelle D(3)	03-2593-P	25.0935	77	25.9392	82	23.5042	61	20.8646	40	16.9	48.1		
METSS RDF-2	03-2582-P	25.4187	81	26.3272	82	17.7436	52	10.4290	65	59.0	19.8	60.0	19.5
METSS RDF-2	03-2583-P	24.7580	77	26.0628	76	17.4580	46	10.3681	59	58.1	23.4		
METSS RDF-2	03-2584-P	24.8814	84	26.0744	77	19.0542	67	12.1470	68	51.2	19.0		
METSS RDF-2	03-2585-P	24.9659	83	26.1110	83	12.7352	45	7.0505	70	71.8	15.7		
Safeway KF Hot	03-2578-P	24.8665	87	25.0256	87	12.7240	72	6.8134	70	72.6	19.5	60.6	17.4
Safeway KF Hot	03-2579-P	24.9998	78	25.1625	86	18.8043	74	11.9538	68	52.2	12.8		
Safeway KF Hot	03-2580-P	25.2359	85	25.3469	80	19.7386	75	8.3605	65	66.9	23.5		
Safeway KF Hot	03-2581-P	25.1018	81	25.3047	79	19.1840	73	12.3557	70	50.8	13.6		
Aviform L50	03-2574-P	25.6288	80	26.4998	83	20.2250	58	14.7618	18	42.4	77.5	60.1	41.6
Aviform L50	03-2575-P	24.8182	80	24.9251	80	14.4560	60	8.4368	64	66.0	20.0		
Aviform L50	03-2576-P	25.6007	81	25.6948	77	13.4706	42	7.3217	53	71.4	34.6		
Aviform L50	03-2577-P	25.1174	84	25.1732	77	17.3874	71	9.8834	55	60.7	34.5		

Carbon-Carbon Brake Friction Materials
Cyclic Heating Test

Carbenix 2110 + antiox ctg		Initial		1^{st} Exposer		1^{st} Heating Cycle		Final Heating Cycle					
Deicer	Lab Sample ID	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2618-P	26.1733	78	26.2234	78	25.8334	78	25.6715	81	1.9	0.0	2.9	13.5
DI Water	03-2619-P	25.9455	83	25.9837	81	25.5940	80	25.3993	73	2.1	12.0		
DI Water	03-2620-P	25.4290	78	25.5072	80	25.0083	76	24.4966	63	3.7	19.2		
DI Water	03-2621-P	25.6029	83	25.6864	76	25.1641	76	24.6366	64	3.8	22.9		
METSS ADF-2	03-2610-P	25.5101	75	26.2145	80	25.4757	80	25.0757	78	1.7	0.0	1.2	6.6
METSS ADF-2	03-2611-P	25.8214	82	26.5262	82	25.8019	83	25.6093	75	0.8	8.5		
METSS ADF-2	03-2612-P	25.9280	85	26.6320	79	25.9192	82	25.5808	77	1.3	9.4		
METSS ADF-2	03-2613-P	25.8416	82	26.5454	78	25.8174	85	25.5860	75	1.0	8.5		
Battelle D(3)	03-2614-P	25.9222	78	26.3033	75	25.5984	82	25.3283	77	2.3	1.3	2.9	6.6
Battelle D(3)	03-2615-P	26.0540	79	26.4627	79	25.7283	83	25.4306	80	2.4	0.0		
Battelle D(3)	03-2616-P	26.2122	79	26.6079	80	25.8733	80	25.6222	75	2.3	5.1		
Battelle D(3)	03-2617-P	25.5971	85	26.1110	81	25.1477	78	24.4458	68	4.5	20.0		
METSS RDF-2	03-2606-P	25.9190	82	26.3313	85	25.7412	72	25.4179	81	1.9	1.2	18.1	45.7
METSS RDF-2	03-2607-P	25.5300	83	26.1074	80	22.9832	39	19.3221	10	24.3	88.0		
METSS RDF-2	03-2608-P	25.5556	84	26.1607	80	23.9626	40	19.9842	41	21.8	51.2		
METSS RDF-2	03-2609-P	25.6637	80	26.2096	80	22.8925	70	19.4167	46	24.3	42.5		
Safeway KF Hot	03-2602-P	25.3230	81	26.0315	73	19.7438	40	9.3286	25	63.2	69.1	40.1	40.4
Safeway KF Hot	03-2603-P	25.9246	81	26.1118	82	17.6825	53	10.8443	67	58.2	17.3		
Safeway KF Hot	03-2604-P	25.4419	84	26.3439	83	25.9246	73	25.4613	81	0.0	3.6		
Safeway KF Hot	03-2605-P	25.3001	77	26.1259	75	20.6101	49	15.3816	22	39.2	71.4		
Aviform L50	03-2598-P	25.5373	82	26.2970	78	19.2575	48	13.5946	29	46.8	64.6	65.4	77.7
Aviform L50	03-2599-P	25.5039	84	26.7093	79	15.1409	20	7.1203	20	72.1	76.2		
Aviform L50	03-2600-P	25.5254	82	26.3993	79	13.4900	33	4.2972	0	83.2	100.0		
Aviform L50	03-2601-P	25.4211	80	26.2755	75	17.9937	73	10.2300	24	59.8	70.0		

Carbon-Carbon Brake Friction Materials

Cyclic Heating Test

Carbenix 4000		Initial		1st Exposer		1st Heating Cycle		Final Heating Cycle					
Deicer	Lab Sample ID	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
DI Water	03-2642-P	25.6581	87	25.6487	85	24.5916	84	23.1004	80	10.0	8.0	8.9	10.2
DI Water	03-2643-P	24.9431	91	24.9494	88	23.9937	84	22.5512	73	9.6	19.8		
DI Water	03-2644-P	25.0958	81	25.1053	81	24.4431	79	23.1261	76	7.8	6.2		
DI Water	03-2645-P	25.4083	88	25.4181	85	24.6527	80	23.3593	82	8.1	6.8		
METSS ADF-2	03-2634-P	25.7410	85	26.3395	77	22.8822	76	19.6736	70	23.6	17.6	22.7	14.6
METSS ADF-2	03-2635-P	25.2760	80	25.8740	82	24.1470	78	18.0430	68	28.6	15.0		
METSS ADF-2	03-2636-P	25.7051	86	26.3015	83	22.1263	80	19.8119	73	22.9	15.1		
METSS ADF-2	03-2637-P	25.9635	86	26.5604	87	24.1466	83	21.8999	77	15.7	10.5		
Battelle D(3)	03-2638-P	24.9803	77	26.3306	77	21.6074	62	17.3363	44	30.6	42.9	33.6	42.3
Battelle D(3)	03-2639-P	25.0395	86	26.3112	83	19.9224	55	14.8209	38	40.8	55.8		
Battelle D(3)	03-2640-P	24.1801	91	25.5398	82	19.4344	61	15.0147	49	37.9	46.2		
Battelle D(3)	03-2641-P	24.7559	82	25.7105	80	21.9648	70	18.5833	62	24.9	24.4		
METSS RDF-2	03-2630-P	24.7586	83	26.3824	82	17.8239	50	7.0330	69	71.6	16.9	79.6	18.7
METSS RDF-2	03-2631-P	25.0878	86	26.6055	86	10.7490	59	0.0000	---	100.0	---		
METSS RDF-2	03-2632-P	25.2613	80	26.4595	85	15.6765	64	5.7677	68	77.2	15.0		
METSS RDF-2	03-2633-P	25.5754	87	26.6745	87	17.1963	62	7.7700	66	69.6	24.1		
Safeway KF Hot	03-2626-P	25.2741	85	25.4776	83	17.5150	47	8.7876	65	65.2	23.5	57.4	18.5
Safeway KF Hot	03-2627-P	25.6692	93	26.0366	85	20.0738	64	14.0748	72	45.2	22.6		
Safeway KF Hot	03-2628-P	25.0497	83	25.4392	80	16.3243	55	8.6376	70	65.5	15.7		
Safeway KF Hot	03-2629-P	26.6399	83	26.0378	79	18.6929	77	12.3382	73	53.7	12.0		
Aviform L50	03-2622-P	25.2887	88	25.3981	83	16.9745	75	5.4935	61	78.3	30.7	70.1	21.2
Aviform L50	03-2623-P	25.5565	78	26.3913	85	19.9307	40	13.6186	66	46.7	15.4		
Aviform L50	03-2624-P	25.1269	85	25.3875	91	17.7273	46	11.2524	70	55.2	17.6		
Aviform L50	03-2625-P	25.4260	85	25.6014	84	6.1882	74	0.0000	---	100.0	---		

Carbon-Carbon Brake Friction Materials

Cyclic Heating Test

Carbenix 4000 + antiox ctg

Deicer	Lab Sample ID	Initial		1st Exposer		1st Heating Cycle		Final Heating Cycle		Weight Loss (%)	Hardness Loss (%)	Average Weight Loss (%)	Average Hardness Loss (%)
		Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter	Weight (gm)	Hardness Type D Durameter				
DI Water	03-2666-P	26.1096	84	26.1011	79	25.7773	83	25.6237	78	1.9	7.1	2.2	3.8
DI Water	03-2667-P	26.0022	83	25.9260	80	25.5129	85	25.2309	81	3.0	2.4		
DI Water	03-2668-P	25.8314	78	25.8052	78	25.4784	88	25.3008	81	2.1	0.0		
DI Water	03-2669-P	25.1864	86	25.1146	80	24.8204	84	24.7154	81	1.9	5.8		
METSS ADF-2	03-2658-P	25.1931	87	25.6744	84	25.3505	80	25.1293	83	0.3	4.6	0.6	5.9
METSS ADF-2	03-2659-P	25.4732	84	25.9534	78	25.6308	84	25.4317	75	0.2	10.7		
METSS ADF-2	03-2660-P	25.6635	88	26.1445	84	25.5921	83	25.3478	83	1.2	5.7		
METSS ADF-2	03-2661-P	25.6744	82	26.1540	83	25.7544	83	25.5247	80	0.6	2.4		
Battelle D(3)	03-2662-P	25.9188	85	26.4150	81	25.6350	82	25.4102	79	2.0	7.1	1.7	4.9
Battelle D(3)	03-2663-P	26.0941	83	26.5216	80	25.8691	80	25.6811	84	1.6	0.0		
Battelle D(3)	03-2664-P	26.1276	78	26.5292	78	25.8883	81	25.6832	85	1.7	0.0		
Battelle D(3)	03-2665-P	25.8377	88	26.3980	77	25.6042	87	25.4485	77	1.5	12.5		
METSS RDF-2	03-2654-P	25.7110	85	26.1994	82	25.8380	84	25.8250	89	0.0	0.0	0.0	1.6
METSS RDF-2	03-2655-P	25.9396	84	26.3995	82	25.9651	85	25.9533	88	0.0	0.0		
METSS RDF-2	03-2656-P	25.4572	83	26.3177	83	25.6418	77	25.6401	84	0.0	0.0		
METSS RDF-2	03-2657-P	25.7449	91	26.5738	84	25.9133	83	25.9202	85	0.0	6.6		
Safeway KF Hot	03-2650-P	25.9196	80	26.1552	78	25.9403	80	25.9429	80	0.0	0.0	1.2	3.2
Safeway KF Hot	03-2651-P	25.1000	85	26.3826	81	24.5485	57	23.9327	82	4.7	3.5		
Safeway KF Hot	03-2652-P	25.4193	89	25.7843	87	25.6367	90	25.3798	86	0.2	3.4		
Safeway KF Hot	03-2653-P	25.9748	85	26.1604	83	25.9732	83	25.9623	80	0.0	5.9		
Aviform L50	03-2646-P	25.9707	80	26.1502	79	25.9261	88	25.9188	83	0.2	0.0	0.1	0.0
Aviform L50	03-2647-P	25.7575	85	26.1314	82	25.7810	86	25.7739	86	0.0	0.0		
Aviform L50	03-2648-P	25.6995	84	25.9519	82	25.6726	90	25.6662	84	0.1	0.0		
Aviform L50	03-2649-P	26.1003	90	26.3625	83	26.0952	93	26.0939	97	0.0	0.0		

Appendix F
IR Window Materials

Aluminum Oxynitride (ALON)

Deicer	Sample ID	Initial Trans.	Final Trans.	% Loss	Avg. % Loss
DI Water	03-1862-P	74.22 86.35	80.12 88.08	0 0	**0.00**
	03-1863-P	79.71 87.88	70.66 82.58	9.05 5.3	**7.18**
METSS ADF-2	03-1858-P	71.64 85.15	79.64 88.57	0 0	**0.00**
	03-1859-P	73.19 86.08	83.84 90.65	0 0	**0.00**
Battelle D(3)	03-1860-P	77.97 88.49	84.5 90.54	0 0	**0.00**
	03-1861-P	85.07 91.16	72.21 83.85	0 0	**0.00**
METSS RDF-2	03-1856-P	76.41 87.36	98.13 98.20	0 0	**0.00**
	03-1857-P	76.7 87.37	85.48 91.09	0 0	**0.00**
Safeway KF Hot	03-1854-P	76.23 87	85.38 90.84	0 0	**0.00**
	03-1855-P	69.04 82.13	74.97 85.05	0 0	**0.00**
AVIFORM L50	03-1852-P	82.79 89.01	83.68 89.27	0 0	**0.00**
	03-1853-P	68.25 81.6	80.37 88.37	0 0	**0.00**

Infrared Window Material – FTIR Transmission Data

Sapphire

Deicer	Sample ID	Initial Trans.	Final Trans.	% Loss	Avg. % Loss
DI Water	03-1838-P	95.54	94.39	1.15	**0.40**
		94.19	93.73	0.46	
		91.13	93.28	0	
		91.01	93.97	0	
	03-1839-P	95.58	95.92	0	**0.39**
		95.56	95.63	0	
		94.13	94.13	0	
		91.54	91.22	0.32	
		92.41	90.79	1.62	
METSS ADF-2	03-1834-P	130.82	95.65	35.17	**31.94**
		134.65	95.48	39.17	
		122.81	94.58	28.23	
		116.48	91.3	25.18	
	03-1835-P	131.04	96.86	34.18	**32.28**
		134.78	96.54	38.24	
		122.86	94.94	27.92	
		118.63	89.85	28.78	
Battelle D(3)	03-1836-P	112.7	97.41	15.29	**17.69**
		111.87	95.28	16.59	
		111.56	90.38	21.18	
	03-1837-P	95.78	97.35	0	**0.69**
		95.6	96.89	0	
		94.35	94.88	0	
		91.4	88.66	2.74	
METSS RDF-2	03-1832-P	123.95	95.62	28.33	**29.08**
		128.48	95.53	32.95	
		120.57	94.22	26.35	
		119.42	90.75	28.67	
	03-1833-P	131.63	94.66	36.97	**33.97**
		135.11	94.82	40.29	
		123.58	93.84	29.74	
		119.11	90.25	28.86	
Safeway KF Hot	03-1830-P	119.53	91.01	28.52	**28.94**
		123.45	91.7	31.75	
		120.74	91.38	29.36	
		120.01	90.97	29.04	
		118.39	92.34	26.05	
	03-1831-P	127.49	95.20	32.29	**30.74**
		130.61	95.01	35.6	
		122.84	94.17	28.67	
		118.79	92.39	26.4	
AVIFORM L50	03-1828-P	128.79	96.45	32.34	**33.95**
		137.98	95.99	41.99	
		119.6	95.22	24.38	
		138.13	93.9	44.23	
		120.94	94.14	26.8	
	03-1829-P	132.05	94.83	37.22	**34.33**
		141.20	94.7	46.5	
		121.26	94.28	26.98	
		120.36	93.74	26.62	

Zinc Selenide (ZnSe)

Deicer	Sample ID	Initial Trans.	Final Trans.	% Loss	Avg. % Loss
DI Water	03-1850-P	1.57	4.91	0	**0.00**
		1.19	4.01	0	
	03-1851-P	3.53	3.02	0.51	**0.73**
		2.99	2.05	0.94	
METSS ADF-2	03-1846-P	1.54	2.51	0	**0.00**
		1.14	1.89	0	
	03-1847-P	3.94	8.62	0	**0.00**
		2.81	5.69	0	
Battelle D(3)	03-1848-P	1.16	1.72	0	**0.00**
		0.69	1.15	0	
	03-1849-P	2.46	10.11	0	**0.00**
		1.55	9.22	0	
METSS RDF-2	03-1844-P	1.68	5.93	0	**0.00**
		1.32	5.63	0	
	03-1845-P	2.44	11.61	0	**0.00**
		1.53	11.37	0	
Safeway KF Hot	03-1842-P	3.12	2.42	0.7	**0.92**
		2.66	1.53	1.13	
	03-1843-P	1.5	4.08	0	**0.00**
		1.08	3.27	0	
AVIFORM L50	03-1840-P	12.81	3.68	9.13	**9.62**
		12.46	2.35	10.11	
	03-1841-P	10.45	5.62	4.83	**6.10**
		9.88	2.51	7.37	